CROSS TALK

►**STRATOPIX** . . . The argument for Stratovision has taken a new turn in the discussion now centering on the expansion of television into the frequencies above 475 mc. As proposed for use in the present commercial channels, airborne transmissions were open to objection on two grounds: First, Stratovision produces a uniform field strength which would provide rural service, but probably could not overcome the high noise levels in outlying cities. Second, one Stratovision station would put off the air a score of ground-based stations on the same channel and thus would foster monopoly. But television on uhf is a different story. The uhf noise level in cities is not so high, so more uniform coverage would be obtainable. Second, it looks as though a ground-based uhf station would have so limited a range (see p 68, this issue) that it would be difficult to cover suburban areas, let alone rural districts. Thus the question of monopoly is overshadowed to a large extent by technical considerations. A comprehensive field test is in order to test Stratovision's capabilities in the uhf band.

►**ARGUMENT** . . . We thought Jeremiah Courtney's "What's Wrong with U. S. Frequency Allocations?" (p 73, August) would start something. It brought a rejoinder from A. L. MacIntosh of the FCC, published in this month's Backtalk column (p 240). We recommend a careful reading of both sides of the argument.

►**ANDB** . . . The Air Navigation Development Board is an agency deserving every support of the electronic industry. Its purpose is to guide and support the development of a system of air navigation and traffic control, the so-called "common system" which will assure safe all-weather flight in military and civil aircraft. Administered jointly by the Secretaries of Defense and Commerce, it will bring together the requirements of the Navy, Air Force and the civil airlines, lay out specifications for equipment and let contracts for development of some 30 items of electronic equipment ranging from ground radar to autopilots. In approximately ten years ANDB plans to spend 80 million dollars on research and development, and Congress has looked favorably on its plans. When the final system is proved in, the amount spent for production of the equipment will run into many hundreds of millions of dollars. This huge program is essential to the future expansion of aviation, which is now stymied by its inability to meet heavy schedules in bad weather. Aviation and electronics have wrestled with this problem for ten years or more. The all-out effort to solve it looms big; it should keep a large segment of our industry busy for the next decade.

►**PARTICLES** . . . Time was when the electron and proton sufficed to describe the structure of our material world. Then came the positron. Then, a decade ago, it became impossible to ignore the neutron. For a while these four particles held the stage to themselves. The neutrino was suggested but, being virtually impossible to detect, it has remained a figment, a dream particle. But lately the cosmic-ray physicists have bumped into the meson, and the flood gates are down. We have positive mesons and negative mesons, mesons of several different masses, all transitory, living long enough only to leave a track in a cloud chamber. Most lately we have the "heavy component" of cosmic rays.

Understandably, the discoverers of these latter-day particles have tended to label them "fundamental." But other physicists, clinging to the hope that nature has a simple core, say it is only a matter of time before mesons will be found to consist of aggregations of electrons and positrons. We hope so too. Things are tough enough without multiple-valued mesons cluttering up the landscape.

Whatever the future may hold, there is some comfort in the fact that, since electronics began, only two types of particle have amounted to anything in practical electron tubes, electrons and ions. If we add the absence of an electron, the "hole" of the transistor, we have the lot, so far as practical electronic engineering goes.

The PROSPECTS

JTAC reports to FCC that service on 475-890 mc is possible only with high field strengths, and predicts megawatts must be radiated by ground-based stations to give results comparable with present service. Suggests study of Stratovision, satellites

WHERE to find additional spectrum space for the burgeoning television broadcasting industry is one of the most perplexing questions now facing the FCC. To explore the prospects of expansion into the uhf band from 475 to 890 mc, the Commission held a hearing late in September and invited the Joint Technical Advisory Committee (JTAC) to present evidence. The JTAC report, a 200-page document, contained an analysis based on information collected by IRE and RMA committees.

The conclusion reached by JTAC is that television on 475–890 mc cannot hope to provide the same grade of coverage over as wide an area as the present channels from 54 to 216 mc offer unless a radically different form of broadcasting, such as Stratovision or satellite stations, is adopted. This sweeping conclusion is based on the propagation characteristics of the uhf band, coupled with performance characteristics of the uhf band and uhf equipment.

The first point made by JTAC is that high field strengths will be required for uhf service. The FCC rules establish a field of 500 microvolts per meter as adequate for residential-rural service on the 54–216 mc channels. The report shows that a field strength ten times as great, or 5,000 microvolts per meter, will probably be required for the same grade of service in the 475–890 mc band. This increase is based on the fact that the effective heights of uhf antennas are smaller, the transmission-line losses substantially greater, and the noise inherent in uhf receiver circuits considerably greater than on the presently-used vhf channels. Thus 2,650 microvolts per meter would be required to produce a 30 db signal-to-noise ratio at the viewing screen, using a dipole at 475 mc, 50 feet of 300-ohm twin-lead cable, and a receiver with a 13-db noise figure.

This figure applies to 6-mc black-and-white service comparable to the present commercial practice. A wideband color-television service at the opposite end of the band (890 mc) would require 20,000 microvolts per meter, even if a directive antenna having a voltage gain of 4 were used. The report indicates that there is much room for improvement in antennas, transmission lines and receivers.

In city districts, the FCC rules provide a field strength ten times that for residential districts, to overcome man-made noise on vhf channels. On uhf channels such man-made noise is not so prominent, so the same increase in field strength may not be required. But a value between 5,000 and 50,000 microvolts per meter would be required for city service on uhf channels.

Coverage Problems

The remaining question is whether such high field strengths can be established at any great distance from the transmitter, using presently available power levels. The answer is definitely in the negative. The RMA Television Transmitter Committee reported to JTAC that the maximum power available from existing tubes, over a 6-mc channel, is 2,000 watts at 475 mc and 500 watts at 890 mc. An antenna power gain of 10 is immediately available, so the effective radiated power ranges from 5 to 20 kw, depending on the position in the band in which the transmitter operates. Such low power levels cannot produce a 5,000 microvolt-per-meter field at a distance of 20 miles, let alone at the 40-mile range typical of present performance on vhf channels.

These conclusions are based on the Norton propagation formula

HOW TO EXPAND?

Television broadcasting today presents a troublesome paradox. In late September, of the 124 television stations authorized by the FCC, less than 40 were on the air. Yet the industry already sees a shortage of channels. Over 300 additional applications for television station licenses await action, and in many heavily populated districts the supply of channels is exhausted. All this, despite the fact that no television station is today meeting its expenses.

To find room for more stations, the FCC is considering the uhf band now reserved for experimentation with color and high-definition monochrome service. The pros and cons of uhf operation were analyzed by JTAC at the Commission's request, with the results here described. Whatever the outcome, to secure maximum service from the proposed new channels, many new techniques must be explored

for UHF TELEVISION

and on measurements of field strength made from an experimental transmitter on the Empire State Building, which operated on 510 and 910 mc. Along one radial, the 5,000 microvolt-per-meter contour was found to fall at 15 miles, despite the fact that the antenna height was 1,060 feet and the figures were converted to an effective radiated power of 100 kw. Along other radials the required field strength was propagated out 30 miles, but fell far short of the 50 miles predicted by the Norton formula.

Even assuming that the Norton formula is applicable to the uhf band, and using the nominal value of 500 feet for transmitting antenna height, the report shows that 5,000 microvolts-per-meter can be delivered to 40 miles only if 214 kw of effective power is radiated. This power is at least 10 times that available from existing experimental equipment. In contrast, the Norton formula predicts, and experience verifies, that 50 kw radiated from a 500-foot antenna at 65 mc will radiate the 500 microvolts-per-meter required for vhf service to 42 miles.

Perhaps most surprising is the fact that when the experimental results from the Empire State transmitter are averaged and substituted for the Norton formulation, similar performance could be obtained (5,000 microvolts-per-meter at 40 miles) only if the effective radiated power is in the range from 5 to 20 megawatts. As the report states, this is more power than has ever been radiated in any broadcast service in any region of the spectrum, and beyond foreseeable attainment of the future.

The report concludes from this evidence that conventional ground-based transmitters may not be suitable for uhf television service and suggests the possibilities of airborne transmitters and satellite stations be investigated as alternatives.

System standards (number of lines and frames, bandwidth, type of sync signals, modulation, etc) are necessary before uhf television service can be instituted. An investigation conducted by an RMA subcommittee revealed that the present commercial standards (6-mc, 525-line, 30-frame picture) are technically feasible for use in the uhf service and if adopted would permit existing vhf receivers to receive the new service with the addition of a frequency converter and a uhf antenna. Since one objective of the study was to find ways of expanding the present service, such compatibility with existing equipment is evidently a basic requirement. But it is possible that modifications of the existing standards, and possibly wholly new standards, could be set up to provide a superior service, while still permitting existing equipment to receive the service. JTAC recommends that this possibility be carefully studied, in the immediate future, before adopting system standards for uhf tests.

The need for development of a color-television service must not be forgotten in the expansion of monochrome service, the report warns. It recommends that the FCC continue to reserve space in the uhf spectrum for the experimental development of color and high-definition monochrome service. No system standards for such wideband services are proposed, however, since JTAC considers that these systems are not yet ready for commercial operation.

Equipment Availability

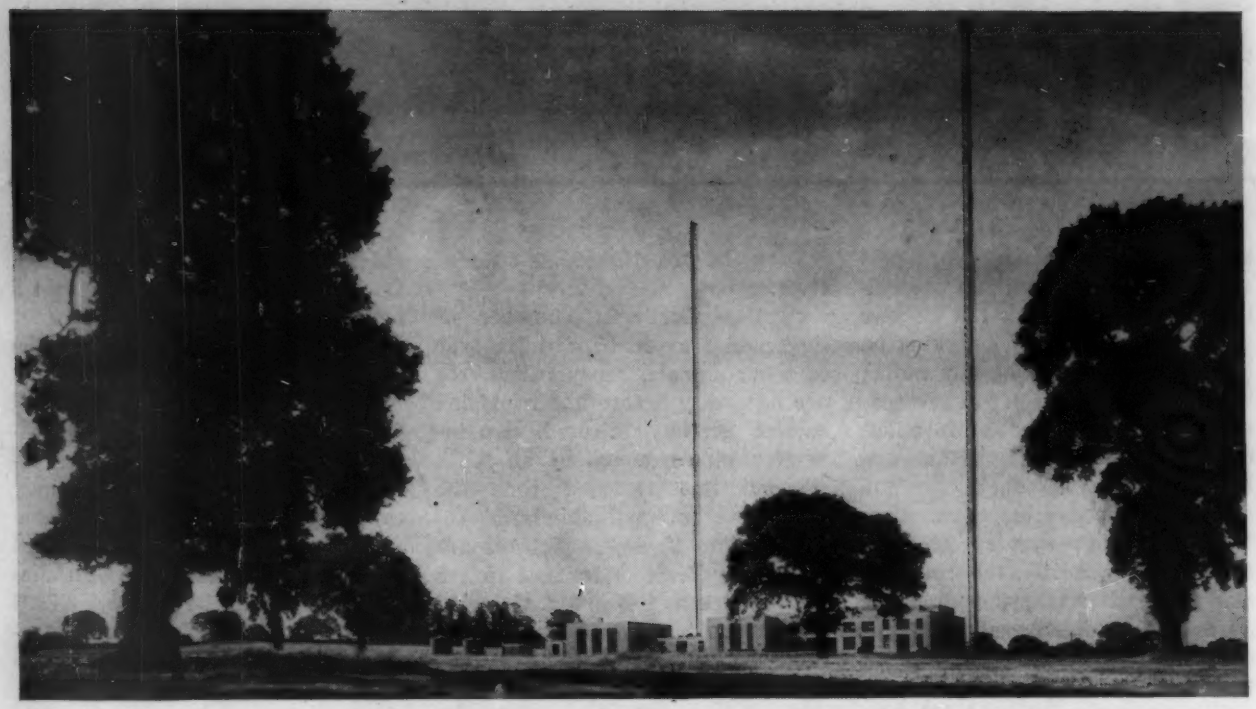
Investigations by IRE and RMA committees revealed that no commercial equipment for transmission or reception of uhf television is now available, and indications are that from 1 to 3 years will be required to develop such equipment to the point of commercial production. One encouraging report was that a new water-cooled tube, capable of producing 10 kw of power at 890 mc, is under development and may be proved in by next year.

Further measurements of propagation effects (especially tropospheric propagation which may cause serious interference far beyond the normal interference range) are required before an allocations plan can be set up. JTAC recommends that such measurements be made during the 1 to 3 year period required for the production of transmitters and receivers suitable for the band. This study should include a detailed field test of the field strengths required for residential and city service, the interference protection ratios required for co-channel and adjacent-channel stations, and the coverage attainable with available transmitter power. Moreover, the special capabilities or limitations of airborne and satellite stations in these respects should be investigated.

Plan for Future Hearing

The JTAC report concludes with a recommendation that another hearing be set by the FCC in approximately six months to receive additional evidence on propagation and coverage. At this hearing, and in the light of additional information, definite systems standards (either the existing standards or variations of them compatible with existing receivers) should be decided upon. The number of channels in the uhf spectrum and the portion of the spectrum to be used should also be decided at this time.

Acting on this information, the industry can then proceed to develop equipment and transmission methods best adapted to uhf service and the service can be instituted commercially as soon thereafter as the propagation studies are completed.—D.G.F.



BBC 200-kw station at Droitwich, England, operating on 200 kc

INTERNATIONAL

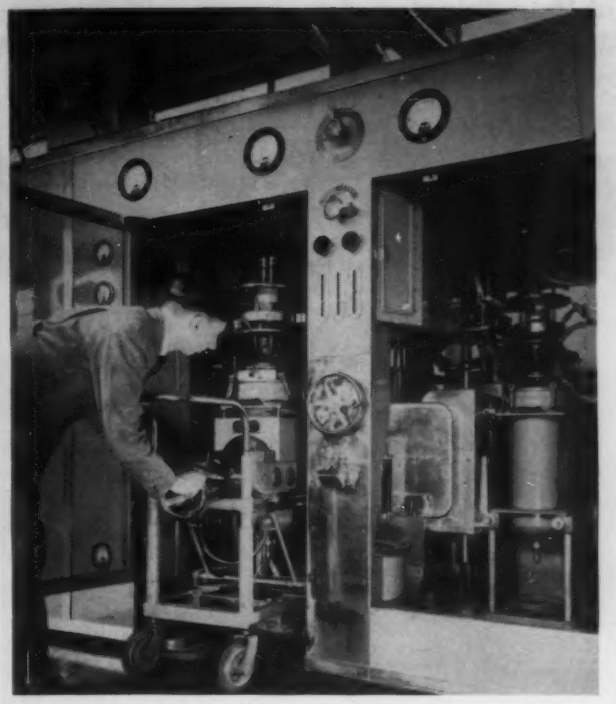
A review of world-wide practices indicates the international character of all European radio broadcasting and the extent of wire-network public-address systems used in many countries. Despite exploitation of radio as a propaganda medium, the potentialities of broadcasting as known in the U. S. and Canada have barely touched much of Europe

BY ITS VERY NATURE, broadcasting is international. Yet few engineers seem to have either the time, or the inclination, to regard it as such. Stuck away in offices working a slide rule, or watching meters at the transmitter, the broadcast engineer too often sees only the domestic side of the picture. For him, the FCC is the god to be appeased, and the creator of the rules under which he operates. NARBA is a word which comes into the conversation when the going gets really technical, but not many stop to think what it means or how it affects their bread and butter.

Yet without it the conditions of the North American ether would be chaotic, and within a very short time many stations would be forced to close down owing to excessive interference. The Standards of Good Engineering Practice and the Rules and Regulations of the FCC are not the composition of only that body, but reflect the contractual obligations proposed by the North American Radio Broadcasting Agreement, which is adhered to by the U. S., Canada, Cuba, Mexico, Newfoundland, the Bahamas and Bermuda.

The system of allocating radio frequencies to the countries of the world requires much more space to give even a brief description than is available here. Moreover, to do justice to the great amount of work and thought which these conferences and conventions entail, the history of their growth would have to be included.

As far as domestic and North American region operations are concerned the most vital controls and regulations spring directly from NARBA, and indirectly from the International Telecommunications Conventions which are held periodically. The most recent one



Changing a 50-kw tube in BBC final amplifier. Dolly speeds work and avoids damage to equipment

One of several pretuned final tanks used at Skelton, England being wheeled into position

BROADCASTING

By JOHN H. BATTISON
Allocations Engineer
American Broadcasting Co.
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concerning the broadcast engineer was the Atlantic City Convention. Up until October 2, 1947, the convention of Madrid, 1932, had governed the radio transmissions of most countries of the world. On January 1, 1949, the operations of 72 countries will be affected by the changes made in the International Union of Telecommunications.

The actual allocating of frequencies and recording of requests is the job of the International Frequency Registration Board, which is composed of eleven members and is charged with the equitable allocations of frequencies and supervision

Table I—License Fees for Private Canadian Broadcasting Stations

Class, and Power of Station in Watts	Service Radius in Miles	Population in Service Radius	License Fee
Class A			
100 or less	18	Under 25,0000	$ 50
		25,000 and under 50,000	100
		50,000 and under 150,000	250
		150,000 and under 500,000	400
		Over 500,000	500
Class B			
250	24	Under 25,000	100
500	31	25,000 and under 50,000	200
1,000	37	50,000 and under 150,000	300
		150,000 and under 500,000	500
		Over 500,000	700
Class C			
5,000	61	Under 100,000	500
10,000	72	100,000 to 500,000	1,000
		Over 500,000	4,000
Class D			
15,000	77	Under 500,000	3,000
		Over 500,000	4,000
Class E			
20,000	82	Under 500,000	5,000
25,000	87	Over 500,000	7,000
Class F			
50,000	100	Under 1,000,000	8,000
		Over 1,000,000	10,000
Class G			
50,001 and over		Fee determined by Order in Council	

Table II—Facilities of Major Countries

Country	Operation	Freq and Max Power in kw	Number of Stations	Number of Receivers	Notes
Afghanistan	Government	h-f 20	4	——	Planned for all to commence in 1948
China	Government	m-f 100	62	——	
		h-f 35	16	——	
England	Government	l-f 200	1	11,233,500 includes	This does not include tele or f-m. Synchronized operations, 10 stations
		m-f 200	53	43,500 tele licenses as	from 1 to 60 kw in one group, seven groups all told, mostly groups of 2
		h-f 100	31	of Feb. 1948	stations. One group consists of two 100-kw stations. Separate license required for car radio
France	Government. Also commercial prewar. Final policy not yet definite	m-f 100	47	8,000,000 approx includes estimated 2,000,000 unregistered	French stations suffered extensive damage when the Germans retreated, but reconstruction progress has been good
Germany		m-f 100	6	8,789,008	Western Allies plans are for eventual return of operations to Germans. These exclude occupation recreational networks. License fees of 2 marks monthly are imposed
(American Zone)		h-f 1	3	Nov. 1947. These are	
(British Zone)		m-f 100	6	approx	
		h-f 25	1	figures	
(French Zone)		m-f 50	5		
		h-f 1	1		
(U. S. S. R. Zone)		m-f 100	9		
		h-f 12	1		
Holland	Final postwar policy undecided. Prewar advertising was allowed	l-f 100	1	1,424,318	
		m-f 60	7	includes	
		h-f 40	6	492,046 relay subscribers	
Iceland	Government, but about 30 min of time daily is sold at 1 kroner per word, for advertising	l-f 100	1	34,692	Government obtains about one third of its income from advertising, also has full powers to curb interference and assists rural districts in radio upkeep
		m-f 1	1		
		h-f 1	1		
Italy	Advertising 2.89% of total programs	m-f 100	29	1,900,000	At present there are 3 networks: The Red, Blue, and Short-wave
		h-f 50	7	Oct. 1947	
Japan	Government and commercial, similar to Australia and Canada	h-f ——	New plans call for 108	——	Final allocation plans now being worked out
Luxembourg	Commercial	l-f 150	1	42,468	License fee 72 francs (Belgian) collected annually by postoffice. Used for anti-interference work
		h-f ——	1		
Norway	Government company	m-f 100	16	566,000	License fees average 20 kroner annually; where reception is poor reduced to 5 kroner, plus tax when buying receivers. Until 1940 advertising was carried. The company assists listeners by providing wind chargers where electric power is not available
		h-f 100	5		
Poland		——	——	675,000 Dec. 1947	
South Africa	Government	m-f 10	16	——	Includes Transvaal, Cape Division, and Natal Division. Programs in English and Afrikaans
		h-f 2	11	——	
Spain	Government	m-f 200	25	——	
		h-f 40	2	——	
Switzerland	No advertising. Transmitters run by one organization, studios and programs by another—both semifederal	m-f 100	6	922,959	License fee is 20 francs. Operation of the radio systems is in accordance with the free spirit of the people of Switzerland
		h-f 100	16	47	
Yugoslavia	Government, no advertising	m-f 20	12	200,000	5 federated republics support their individual stations by license fees. Propaganda use to all parts of the world except China and Japan. N. America beam completed by 1951
		h-f ——	2		
		l-f 50	10		

to ensure that they are used to the best advantage. All the documents of the IFRB are written in English, French, Chinese, Russian, and Spanish, with French as the official language. The Provisional Frequency Committee (CPF) is the direct result of the Atlantic City Convention, and met at Geneva in January 1948 to prepare a new international list of frequencies for the use of IFRB. In spite of these agreements, countries have been known to use more power than that authorized, or to jump frequencies.

Fortunately such happenings are relatively rare.

The Canadian system of broadcasting is very similar to that of the United States in that it allows private commercial broadcasting, but it also has its own government network system working in competition with the private broadcasters. The Department of Transport is the regulatory body in this instance, although the CBC actually passes on the applicants, thus, in effect, controlling its own competition. A fact which may have escaped the notice of a large number of U. S. broadcasters is the license fee which has to be paid for the privilege of operating a commercial broadcast station. This fee ranges from $50 for a 100-watt station to $10,000 for a 50-kw station, as seen in Table I. Plans are afoot to increase these fees. The listener also has to pay a fee of $2.50, even in areas where reception of CBC stations is impossible.

The United States side will be familiar to all readers, but perhaps the European aspect may not be. In fact the writer has often been amazed by the many times engineers have asked what body exists in England and Europe similar to the FCC. In each case the answer is none; and as we shall proceed to show, the need for a similar regulatory body does not exist, owing entirely to the different approach towards broadcasting.

Human nature being what it is, and engineers being, by virtue of their common interest, of a similar type, it is only natural to expect, and to find, that radio has progressed along very similar lines in most countries. An advance in one phase in one country is matched by an advance in the same field in the next, and so on. Although individual differences may cause slight changes in equipment operation and layout, the principles of construction follow somewhat similar lines, as may be seen in some of the illustrations.

Operational Procedures

As a result of engineering parallels one might expect the business procedures and principles of the various nations to be similar. They are not. The U. S. and Canada have somewhat similar operation, but there are not many countries that allow commercial broadcasting by private companies; although wherever the U. S. influence is felt, a trend towards commercial operation is noticed. In most nations of the world radio is the voice of the government, and is used as a propaganda tool by the party in power.

In general it will be noticed that the majority of countries do not permit sponsored or commercial broadcasting. However, a few favor limited commercial broadcasting along somewhat similar lines to the Canadian system. Generally speaking, where this type of operation is allowed, the government runs the broadcasting system and collects the revenue from it. Receiver license fees are collected even where sponsored broadcasting is the rule. As far as the writer has been able to ascertain, such is the practice in every country except the United States of America. In countries where commercial broadcasting is allowed, or advertising is accepted, the license fees are sometimes used for improvement of the service to listeners.

A large number of foreign countries have strict laws concerning the use of apparatus which causes interference to radio reception. And in these countries the authorities are empowered to trace it down, and cause the owners of the offending equipment to modify it at their own expense. As television becomes more and more general in this country, it appears that a similar measure may have to be invoked.

The incidence of relay exchanges, and "wire broadcasting", in Europe and other countries, is much greater than is generally realized. A number of factors contribute to this, among them being the extremely poor conductivities in many of the mountainous countries of the continent, the lack of facilities for the domestic construction of receivers, the lack of money, either by the government or the listeners themselves for providing equipment, and the extremely poor reception conditions obtaining in many places. An example is the Gold Coast of West Africa, where for five shillings a month ($1) a loudspeaker may be leased together with a wire connection to the local relay exchange. This is an ideal provision for the inhabitants and well within their means. In many parts of Europe high and medium-frequency carrier-current systems are used over power and telephone lines. Some of these relays provide only the program of the national station; others also act as local stations and provide programs from local studies in addition. Of course, the great disadvantage of all these systems is the dependency on a physical connection. In the event of war a large part of the population could be denied broadcast intelligence by a few skillful saboteurs. This possibility is particularly true of Russia and many of the eastern states of Europe. In some of the villages in these areas only one loudspeaker and receiver is available for perhaps 500 people.

The very nature of the terrain in so many parts of Europe is an added handicap. A glance at any map will show large areas of mountainous country where reception is extremely poor. In view of these handicaps, it is interesting to reflect on the large number of high-power stations in Europe. High power is considered to be 60 to 500 kw. In the writer's opinion there is no doubt that the European answer to the coverage problem is large-scale synchronized operation of high-power stations, thus providing a nationwide groundwave signal from nationally operated transmitters. Either by accident or design, the local station and program, such as are known in this country, are virtually nonexistent. Possibly it is by design, for single sources of high-intensity groundwave service can be used more effectively with one propaganda program to influence a country than a number of small stations with varying ideas of program content.

In this respect, the Balkan countries are the worst situated. Conditions of low income per capita and scattered population combine with extremely mountainous terrain to present a very difficult problem. Very rapid attenuation of groundwave is experienced in these small countries and they are usually too

small to utilize skywave for night service.

In certain countries where commercial and government broadcasting is allowed, operation is along rather similar lines to that of the CBC and the private broadcasters in Canada. For example in prewar days, Radio Luxembourg on 232 kc with 150 kw, provided an excellent day and night signal to more than 50 percent of Great Britain. This station carried limited commercial programs in English, as well as programs addressed in the national tongue of Luxembourg. Other stations such as Radio Paris, Radio Lyons, Toulouse, Radio Normandie, and Hilversum on the medium-frequency band, carried sponsored programs for both home and overseas, that is, British Isles consumption. These stations enjoyed a popularity equal to or greater than that of the BBC stations, especially among the younger people who were more receptive to the dance and light music which formed the major part of the programs. The International Broadcasting Company programmed some of these stations, with operation by nationals of the countries in which they were located.

It is simpler to list those countries where receiver licenses are not required than to list those requiring one! America is the shining example of free listening, although the principality of Monaco with its three stations is likewise untaxed. As a result of this almost universal imposition of license fees, a fairly accurate check can be maintained of the number of listeners throughout the world. It is not difficult to evaluate illegal operations. In 1942, it was estimated that there were 400,000,000 listeners. This world total can be broken down to show 29,393,000 radio homes in the U.S.A., against 51,986,000 in the whole of Europe and Russia. The terrific impact of radio in Europe is only now commencing to be felt and as more sets become available great mass reactions may be expected.

A problem peculiar to a number of European countries, and one with which the United States is not faced, is the provision of programs and radio services to colonies, dominions, and protectorates. Sometimes this service is achieved by high-frequency transmission from the mother country for direct reception, relying on these broadcasts to combat adjacent country propaganda interference. An alternative is to build local stations and program them locally, supplemented by relays from home. The latter is better, for it insures a service not dependent on the ionosphere layer, and not requiring different frequencies for different times of day.

Practically every European country operates at least one low frequency transmitter between 150 and 285 kc together with high power up to 200 kw. This combination usually results in a large part of the population receiving a fairly reliable single program service. However, secondary service has to be depended upon to a much greater extent than it is in America, and as a result relay exchanges are numerous and extremely popular.

Table II presents a brief summary of conditions in a number of countries. A breakdown of U. S. broadcast operations is given in Table III.

European Problems

In France in 1944 there were approximately 34 stations under government and private control. At the end of the war there were only five of any considerable power remaining. At present, there are two countrywide networks known as the National and the Paris networks. Recently, a third program heard only in Paris and the suburbs has been added. This program may later develop into a third network so that the combination will prove similar to the three BBC program services. Thirteen transmitters in the National network cover about 80 percent of the population and ten in the Paris network provide coverage of 66 percent. Some areas hear only one service.

Table III—Broadcast Stations in the U. S.

	July 1, 1947	July 1, 1948	Increase
A-M	1,795	2,034	239
F-M	918	1,020	102
Television	66	109	43
Television (experimental)	81	124	43
Educational	38	46	8
International	37	37	0
Remote Pickup	583	571	(−12)
Other	33	26	(−7)
Totals	3,551	3,967	416

In July 1947, a new coaxial cable was put into operation between Paris and Toulouse. This span of approximately 490 miles requires the use of 42 repeater stations. Unfortunately, no details are yet available concerning its frequency response. A new transmitter with a power of 100 kw operating on 895 kc went on the air September, 1947, at Lyons-Tramoyes, and it is believed this is the first new one to be built since the war.

Before the war, Italy maintained three networks consisting of 40 stations in the m-f-band varying up to 100 kw. Nine short-wave transmitters used power up to 100 kw for broadcasts to Italian-dominated territories.

Belgium provides a good example of the dual language problem. Before the war the state operated two 15-kw transmitters at Brussels providing programs for the Walloons and Flemings, in French and Flemish; and 16 small privately-owned stations carried sponsored programs for local and regional consumption. Today, Belgium is rapidly rebuilding a first-class system out of the ruin left by the war. A 1-kw f-m transmitter on 100.1 mc is operating at Brussels, with two or more planned for Antwerp and Liege. It is suggested that an f-m network may be set up at a later date. However, this does not affect in any way the instant plans for a complete a-m network providing nationwide primary service.

Czechoslovakian broadcasting is governed by the law of March 23, 1923, and the decree of February 8, 1925. These reserved to the State the right to grant concessions to the use of the ether. The Ministry of Post may grant to individuals the right to operate a station, but there have never been any such grants. The Czechoslovakian Broadcasting Company, in which the government holds most of the shares, is the only source of broadcasting in the coun-

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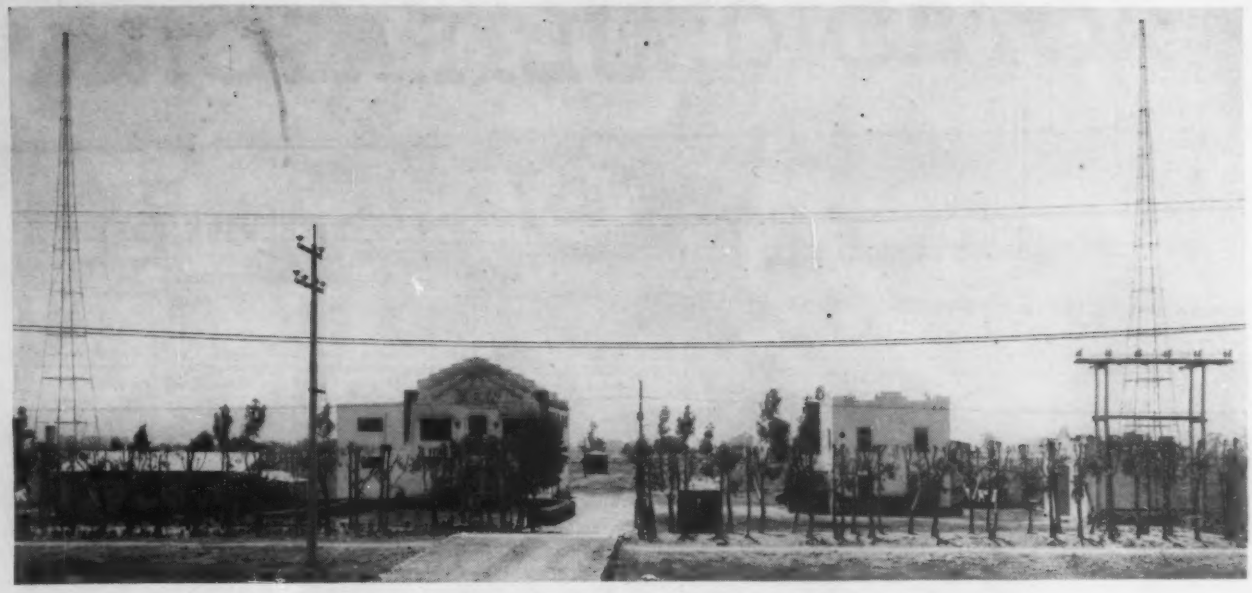

Mexican stations XEW and XEWW, showing a flat-top transmitting antenna (RCA photo)

try. Although nominally a private company, the State virtually controls its operations. About 1,600 people are employed and the organization is administered by a board of three members in Bohemia, five in Slovakia and the Ministry of Information. There are approximately 2,000,000 licensed listeners in the country.

Before the war, the Czechoslovakian radio system was one of the best in Europe. It operated eight stations, ranging up to 120 kw at Prague I. A number of these were destroyed during the war, but they are being replaced and in last December a new one of 100 kw on 1,204 kc was brought into operation near Presov. Incidentally, it is a European custom to identify stations by their location rather than call letters, and to carry it a step further, when two or more are located in the same town, they are labeled Prague I, Prague II, and so on. (This would be a little unwieldy in New York!)

At the time of writing, Poland operates nine medium-frequency transmitters and one low-frequency transmitter. The most powerful of these is Warsaw I with 50 kw on 758 kc. Licensing is employed as a means of raising money, but here it is rather illuminating to note that imprisonment is not provided as a penalty for failing to register, as in most countries, but a fine equal to six months' license fee is imposed. The normal license fee is paid monthly, and is graded according to the size of the receiver, and the class of the owner, peasants, workers, clerks, pensioners, and military paying from half to two-thirds less than "other persons."

Polskie Radio, the official name of the organization, maintains a technical section which assists listeners in assembling or installing receivers. At the end of 1947 there were about 600,000 subscribers to wire broadcasting service. Special importance is attached to these installations in mining areas and it is intended thus to service ten large industrial centers in Silesia, where reception conditions are extremely poor.

Radio in Russia is, of course, a government service. The existence of two hundred different peoples in the Union, the extreme poverty of a large part of the population, and enormous areas to be covered all serve to direct radio towards group-listening practices. There were approximately 90 stations, one more than there were a-m stations in New York State, and 39 less than in California, at the end of 1947. The principal station, Moscow-Komintern, has a power of 500 kw; eleven others have 100 kw each. The exact number of shortwave stations for the Asiatic regions of the U.S.S.R. is not known since reports vary, but well over 50 frequencies are used.

Radio reception in this tremendous area varies from place to place, but on the whole, conductivity is on the low side. To assist dissemination of programs a system of relay exchanges distributing the national program by wire was set up. In 1937 there were 7,000 of these exchanges, and by now there must be many more. They are similar in effect to United States local stations, except that they carry one-party propaganda only, and on a public-address basis.

Whenever radio men from different countries get together the conversation eventually turns to sponsored versus government radio. Without considering the merits of the case, the popularity of the American system is attested by the fact that last year a British company offered 300,000 crowns to the Danish Government to be allowed to put a transmitting station on the Faroe Islands. When this offer was turned down, the offer was increased to a figure of half their annual profits. So far as the author is aware, a decision has not yet been reached.

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ULTRASONIC

By BENSON CARLIN
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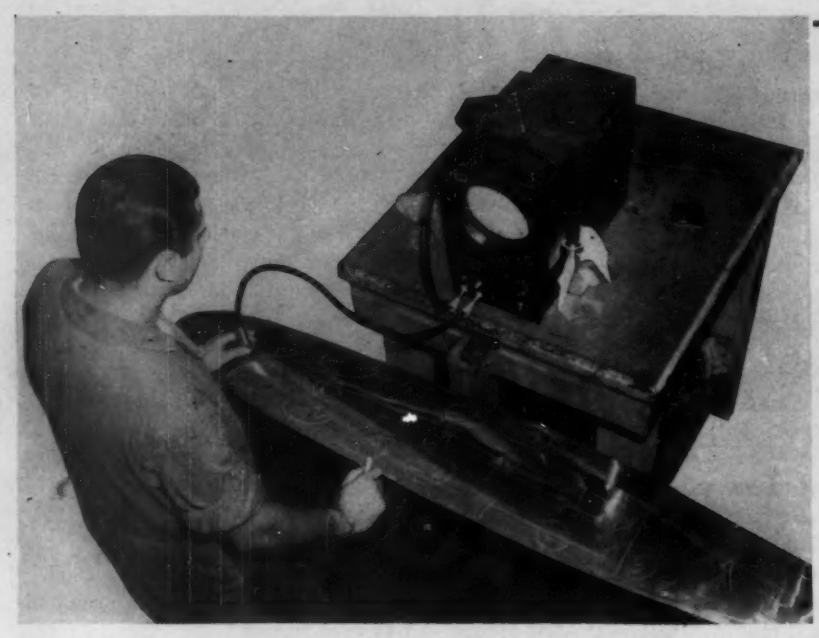
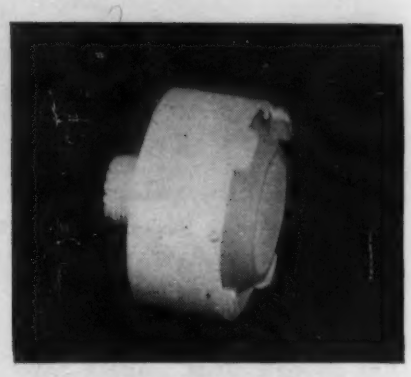


Wall thickness readings chalked in at various points on surface of hollow propeller



Crystal transducer searching unit

ULTRASONIC METHODS are being successfully applied to the testing of materials, using various instruments.[1] One of these is the Reflectogage, based upon the principles used in the Sonigage[2] originally developed by General Motors.

This device utilizes electronic methods of generating and receiving ultrasonic waves which are transmitted through the article under test. These waves are reflected within the material either by its opposite side or by a flaw or discontinuity, so that the thickness of most parts can be measured or the presence of flaws indicated. The accuracy of measurement can be made almost as great as the operator desires but in an ordinary commercial instrument such as the one described it is approximately 2 percent of the thickness of the part, regardless of what the thickness may be.

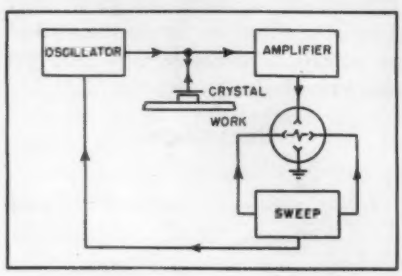


FIG. 1—Block diagram of equipment

Parts ranging from a few thousandths of an inch to four inches thick can be measured by variations of the basic method. The present commercial instrument reads directly in the range from 0.025 to 0.300 inch in steel and measures up to 4 inches by harmonic methods. It measures the thickness of material forming pipes, tanks, and vessels which can only be reached from one side of the wall. Such measurements were formerly made by drilling a hole and reading the thickness by mechanical means.

Not only metals but glasses and certain plastics can be measured. The use of the instrument is particularly valuable in cases where the material is formed into a closed vessel or long tube. For example, hollow propeller blades are being widely tested at present. It was formerly impossible to measure these sections by any known means. Lack of bond between similar or different materials can also be indicated either by changes in the amplitude or in the location of the indications on the instrument. Eccentricity of bore can also be measured quickly and easily. Other applications are the testing of knife blades made of several sections bonded together, and of shell cases for separations within their wall sections.

Ultrasonic Principles

Ultrasonic waves commonly used in testing or gaging can be defined as sound or vibrational waves of very high frequency ranging between 100 kilocycles and 10 megacycles. For purposes of measurement, they may be considered to travel through a material with a fixed velocity that depends in a complex way upon the density and elasticity of the material.

The tables give experimental velocities and wavelengths for ultrasonic waves. Such waves are strongly reflected by an interface and will ordinarily return toward the source which produces them. Standing wave patterns are set up in the manner of electrical waves; the patterns are determined by the dimensions of the medium of travel and by frequency. The ultrasonic gage indicates the frequencies at

THICKNESS INDICATOR

Nondestructive testing and gaging device gives visual display. Equipment comprises motor-driven variable frequency oscillator, contactor-initiated R-C sweep, crystal transducer, and cathode-ray tube. Graduated screens provide direct readings

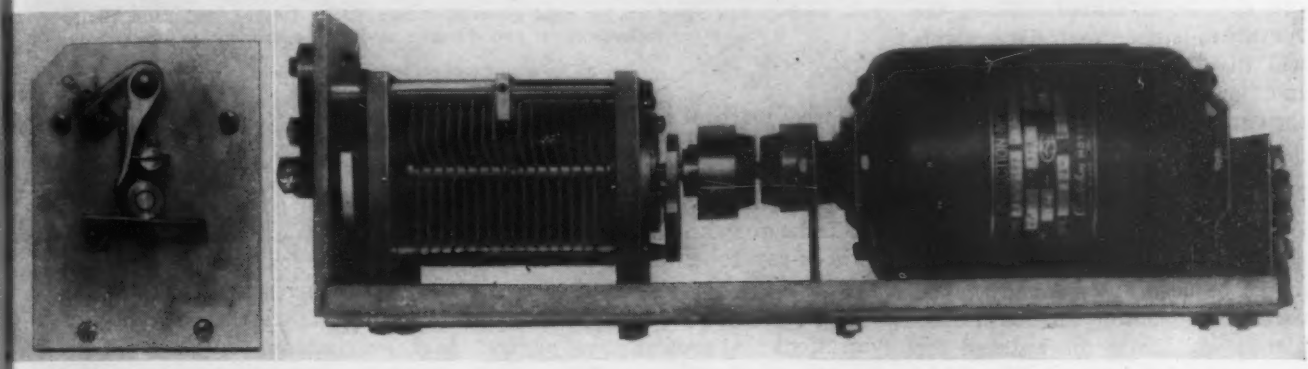


FIG. 2—Motor-driven capacitor for variable-frequency oscillator. Contactor for initiating sweep is shown in detail at left

which resonances take place. Because the velocity of travel is fixed, this action is equivalent to measuring the thickness of the medium, and the instrument may therefore be directly calibrated in thickness.

The operation of the instrument depends upon the fact that the amount of energy required to drive a system varies with its dimensions, —that is, resonances occur when ultrasonic wavelength has a specific relation to the thickness of the part and at this point there is a great increase in the vibration of the wall being measured. As a result, the plate current in the driving oscillator increases sharply. Any part can be put into such resonance depending on its dimensions, elastic characteristics, and density.

The lowest frequency at which resonance occurs is called the fundamental; and subsequent ones, harmonics. The frequency deviation between any two consecutive harmonic frequencies is equal to the fundamental. Therefore, when either the fundamental or the difference between two consecutive harmonics is known, the thickness (T, in inches) is determined by the relation $T = S/f$ where S is half the velocity of sound in inches per second, and f is the frequency in cycles per second. For steel this becomes

$$T = 121{,}000/f$$

Harmonic indications can be directly used to calculate thickness from the relation

$$T = R_1R_2/(R_2 - R_1)$$

where R_1 and R_2 are thickness readings of any two successive indications and R_2 is thicker than R_1.

It should be noted that the thickness is read over a small area directly under the crystal. When the thickness varies sharply within that section, readings cannot be obtained. However, satisfactory results can be obtained even where a liquid or solid is contained against the reflecting surface.

Most materials transmit ultrasonic waves well[5] and can therefore be measured. However, this is not true for materials which have very high internal damping or absorption. Most metals are in the first class, and each different material requires a separate calibration screen for use with the instrument. Alloys in which velocities vary greatly also require separate screens.

In cases where the medium under test is not electrically conducting, a metallic face must be placed over the front of the crystal search unit so that a suitable ground return can be made to the instrument. The interface between the crystal and work will interrupt the passage of ultrasonic waves unless it is filled in with some form of couplant such as transformer oil.

It is also important that the sur-

Table I—Velocities in Common Materials

Material	Velocity in cm per sec × 10^5
Air	0.331
Alcohol	1.44
Aluminum	6.22
Bakelite	2.59
Brass	4.43
Copper	4.62
Glass	4.9–5.9
Lead	2.13
Magnesium	2.33
Mercury	1.46
Nickel	5.6
Polystyrene	2.67
Quartz	5.75
Steel	5.81
Transformer oil	1.39
Water	1.43

face of the part be fairly smooth. In general, most metallic surfaces are satisfactory or can be made so with a hand grinder. The back or reflecting surface must be smooth for if it is very badly pitted, the energy is scattered and it becomes difficult to make satisfactory readings. However, measurement can sometimes be made even when the reflecting surface is pitted by limiting the crystal to a small area.

The thickness of curved sections can also be measured. When the curvature is not great, flat crystals will give satisfactory indications. In other cases, crystals ground to fit the curved surface are necessary.

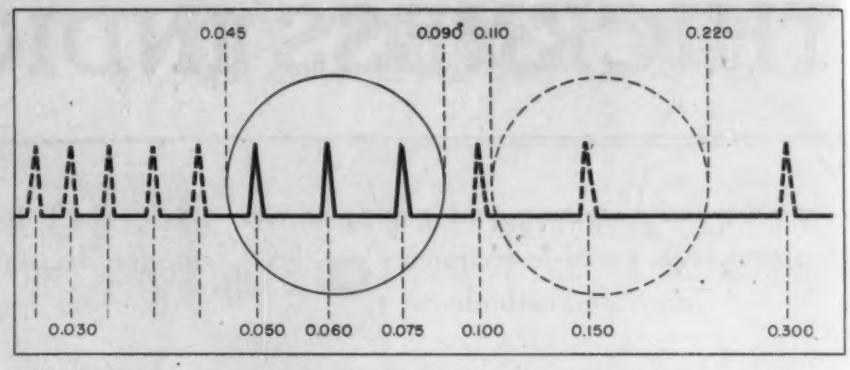


FIG. 3—Harmonic spectrum for steel piece 0.300-inch thick. Dashed and solid circles show indications for two different modes of operation

Electronic Principles

In a simple instrument of the resonance type, an oscillator with a milliammeter in its plate circuit might be used. A manually tuned variable capacitor can be slowly turned and the meter watched for changes in plate current. The thickness of a known part is calibrated against current dips and calibrations marked on a suitable tuning knob. Unknown parts can then be checked and the thickness read directly from the knob. This type of device would prove inconvenient because each successive test requires a laborious readjustment of the instrument before a reading can be taken.

A block diagram of the Reflectogage is shown in Fig. 1. It is an entirely automatic instrument, comprising a variable-frequency oscillator whose frequency is swept by means of a motor-driven capacitor, a sweep generator, an electronic sweep amplifier and signal amplifier, an indicator in the form of a cathode-ray tube, and a searching unit.

The oscillator produces electrical variations that are impressed across the crystal search unit. The rotation of the tuning capacitor continually changes the frequency of oscillation throughout an optional tuning range. The same mechanical device also contains a contactor or switch unit for producing a sweep voltage by discharging a capacitor through a resistor. This contactor, shown at the left of Fig. 2, is so adjusted that it fires the cathode-ray sweep at the beginning of each successive variation in frequency, that is, at the high-frequency end of the range, and the cathode-ray beam is swept horizontally across the screen once for each revolution of the capacitor. As a result, each point along the beam corresponds to a particular frequency of oscillation. The scale is then calibrated in thickness for the parts under test, increasing from left to right. As energy is returned from the part, variations in the voltage across the crystal and across the amplifier cause the beam to be deflected vertically. These pips are the thickness indications.

If the oscillator were adjusted so that it operated over a very wide range the indications received would look like those in Fig. 3. However, in ordinary use it is convenient to limit the range so that only one marker or pip is received. This pip indicates a resonance in the material and although it may not be a fundamental, the range is ordinarily chosen so that it is. The instrument can be operated at almost

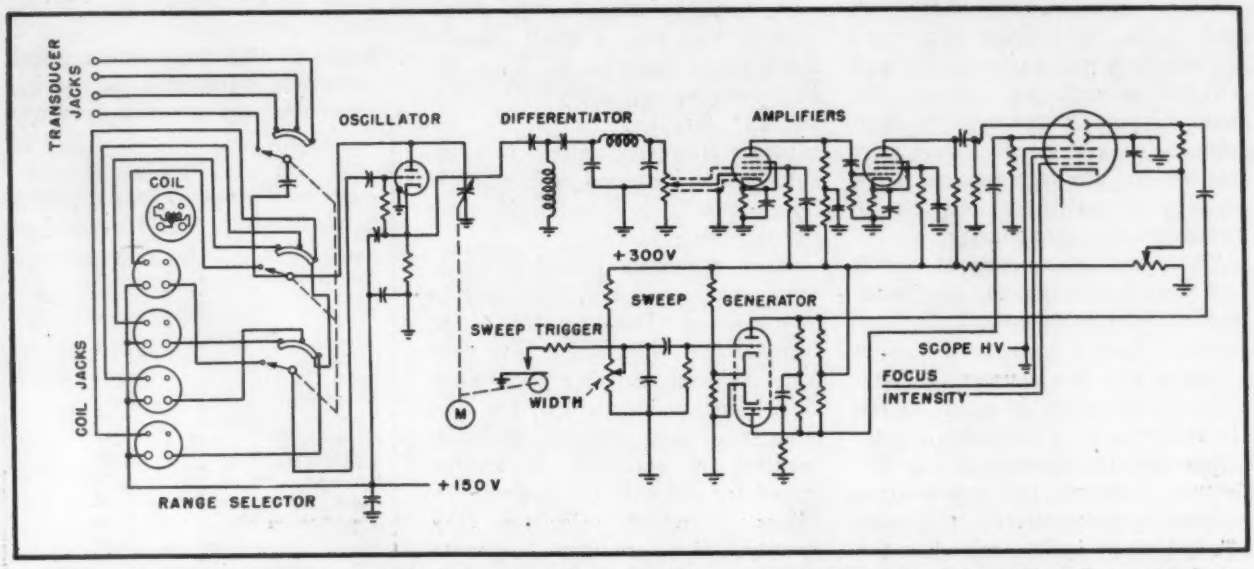


FIG. 4—Schematic circuit diagram of the Reflectogage. Conventional power supplies for plates and scope have been omitted

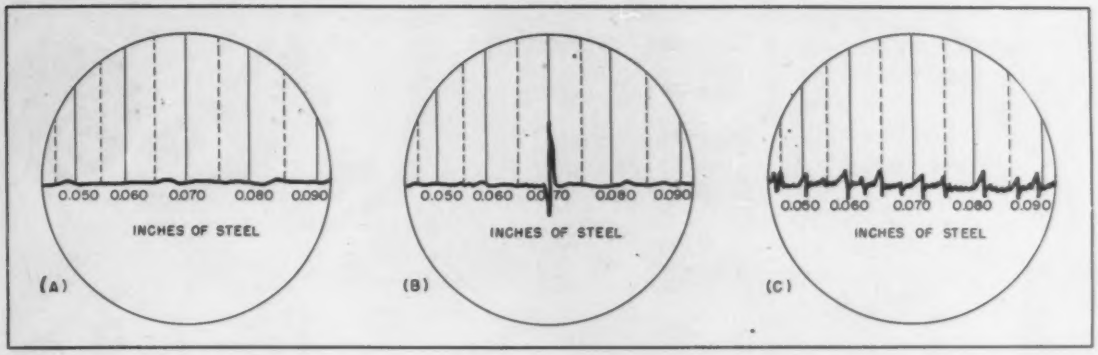


FIG. 5—Typical visual displays: (A) sweep without thickness indication; (B) fundamental thickness indication; (C) harmonic indications

any convenient frequency by substituting plug-in coils, but it is basically a 4-range unit. Range 1 is 0.025 to 0.050 in., Range 2 is 0.045 to 0.090 in., Range 3 is 0.080 to 0.160 in., and Range 4 is 0.150 to 0.300 in. A total frequency range from 400 kc to 5 mc is required.

Crystal Transducer

The energy produced by the electronic oscillator is impressed across the X-cut quartz crystal, illustrated, which transforms the electrical voltage into longitudinal physical vibrations. This crystal is usually either ½ or 1 inch in diameter and mounted in a spring holder so that it is always supported at a fixed pressure against the work. The ultrasonic waves then travel perpendicular to the face of the crystal and are essentially limited in their cross-sectional coverage to a projection of the crystal face. The part of the work tested is therefore only that directly under the crystal and the instrument does not in any way integrate thickness readings over considerable areas.

The crystal resonance frequency is chosen to be somewhat greater than the highest frequency of electrical oscillation employed in that range so that the output is essentially constant and spurious crystal resonances do not appear as indications on the sweep.

Circuit Details

The oscillator output is connected to a vacuum-tube amplifier as shown in Fig. 4. The variations in plate current are separated, amplified, and finally displayed on the cathode-ray tube. The actual variations in plate current range from 2 to approximately 25 percent. The pips produced may be from ½ inch to 3 or 4 inches in height but the instrument is ordinarily operated with the markers about ½ inch high to give a clean base line and sharp vertical indications.

Table II—Wavelengths in Centimeters in Common Materials

Material	Frequency in megacycles			
	0.5	1	2.25	5
Air	0.0688	0.0344	0.0153	0.00688
Aluminum	1.244	0.622	0.277	0.124
Bakelite	0.518	0.259	0.115	0.0518
Brass	0.886	0.443	0.196	0.0886
Copper	0.924	0.462	0.206	0.0924
Glass	1.040	0.520	0.231	0.104
Lead	0.426	0.213	0.0947	0.0426
Mercury	0.284	0.142	0.0632	0.0284
Polystyrene	0.534	0.267	0.119	0.0534
Quartz	1.150	0.575	0.255	0.115
Steel	1.162	0.581	0.259	0.116
Transformer oil	0.278	0.139	0.0618	0.0278
Water	0.290	0.145	0.0645	0.0290

The general shape of the voltage variation in the plate circuit is that of a resonance curve and is therefore not so sharp as is desirable for indicating purposes. The signal is therefore differentiated by a series of filters and appears on the face of the tube as a sharp increase followed by an equally sharp decrease of voltage. The point at which the changeover from increase to decrease occurs is the one at which thickness is ordinarily calibrated.

Calibration is carried out by placing over the face of the cathode-ray tube a transparent plastic screen on which vertical lines are inscribed for various thicknesses. A different screen must be used for each material and also for each range of frequencies. Additional screens could be made for operating at harmonic frequencies.

The appearance of the final signal may be more completely visualized from Fig. 5, in which the cathode-ray trace without resonance signal is shown at A; B is the trace with a single fundamental indication; and C illustrates the appearance of the trace with several harmonic indications. In B the thickness of the part is within the range of frequencies for which the instrument produces fundamental oscillations. At C the thickness of the part is much greater than the maximum fundamental possible on that range.

Work connected with the instrument was carried out with the aid of W. Doniger and T. C. Nehrbas.

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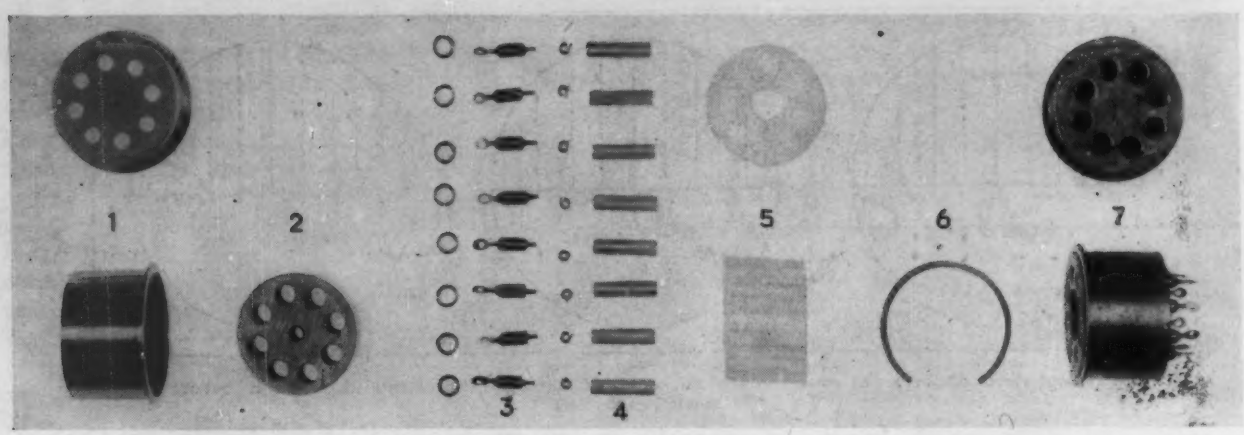

FIG. 1—Component parts (1, 3, 4, 5, 6, 7) and metal assembly jig (2) of a hermetically sealed octal socket

Hermetically Sealed Electronic Components

By W. J. LEISS, G. R. MOLTRUP, J. H. SLATON and A. H. WAYNICK

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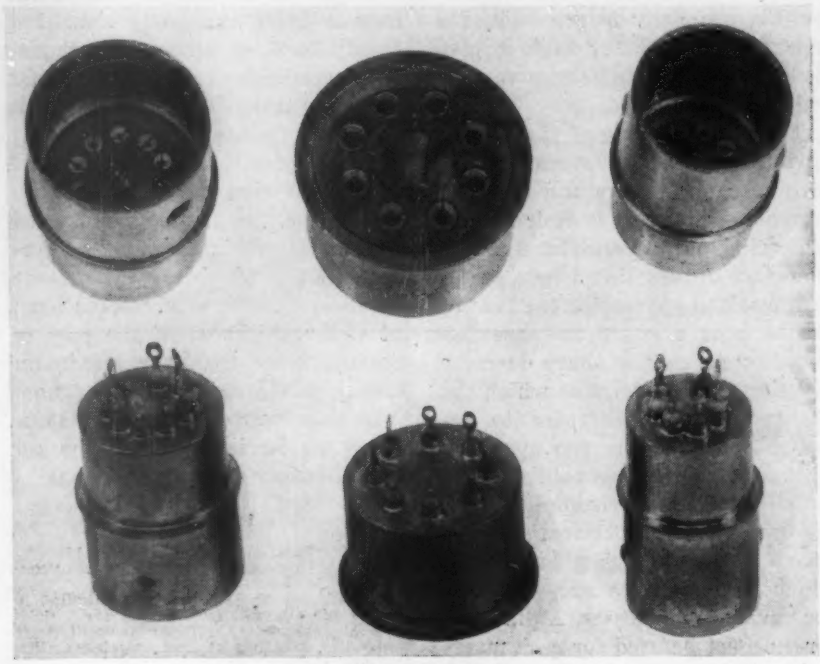


FIG. 2—Top and bottom views of assembled nine-pin, octal and seven-pin hermetically sealed sockets

CONSIDERABLE EFFORT has been expended during and since the end of the war by numerous laboratories attempting to devise means of protecting electronic equipment in use against numerous deleterious environmental factors such as high humidity, fungus growth and salt water spray. The Ordnance Research Laboratory of the Pennsylvania State College, which is interested in electronic developments for the U. S. Navy, has designed hermetically sealed plug-in units, assemblies and complete devices.

By utilizing the components and techniques to be described it has been found possible to seal hermetically an entire electronic chassis as well as subassemblies and components. By so doing, the major problems of protection of electronic equipment during storage, shipment and use against high humidity, fungus growth and salt-water spray have been solved. The servicing problem has been greatly alleviated by the use of hermetically sealed plug-in components. In the case of more complex devices, the servicing problem has been further simplified by the use of hermetically sealed

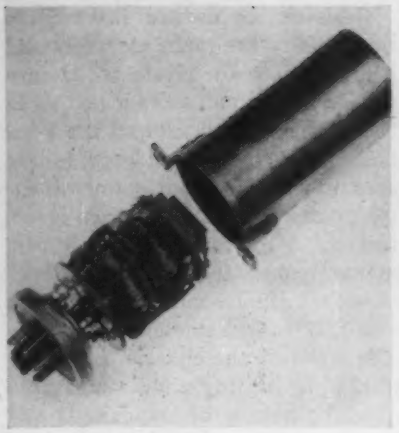


FIG. 3—Plug-in oscillator tank circuit using the sealed construction

FIG. 4—Two-tube sealed subassembly that plugs into a larger chassis

Sealed plug-in units such as tubes and sockets, transformers, relays, capacitors and tuned circuits are utilized in construction of subassemblies and complete chassis that are also hermetically sealed to provide protection against high humidity, salt-water spray and fungus growth

plug-in subassemblies which, in themselves, may generally be so constructed as to be simple to test.

For relatively simple electronic devices all of the critical or high impedance circuits have been placed in one chassis, the entire chassis then being hermetically sealed. More complex devices have been broken into subassemblies which are in themselves constructed in plug-in type hermetically sealed containers. In either case the maintenance and/or servicing procedure, aside from replacement of tubes, transformers, relays and other standard hermetically sealed components, involves the replacement of the entire hermetically sealed chassis or subassembly in case of electrical or mechanical failure. By utilizing this construction, the problems of protection against humidity, fungus growth and salt-water spray may also be satisfactorily taken care of by proper choice of materials.

Sealed Sockets

Hermetically sealed tube sockets for octal and seven and nine-pin miniature types are made up from the components shown in Fig. 1, and examples of the resulting sockets appear in Fig. 2. Use of these sockets results in a gas and vapor seal of the chassis interior relative to its exterior. The sealing is accomplished by means of glass and metal surfaces, with all materials exposed to the exterior so chosen as to avoid surface condensation leakage paths when exposed to humid atmospheres.

In mounting, a hole which is just large enough to permit entry of the socket body is punched in the chassis. The latter must be hot tin dipped to permit soldering. The socket is then placed in the hole and is supported therein by a protuberance at the top of the octal socket and near the center of the miniature sockets. The socket is then soldered into place with a solder ring and, if desired, by cylindrical soldering irons designed for this purpose. The portions of the miniature socket shells above the chassis surface fit standard shields.

As shown in Fig. 1, the socket body is a hot tin dipped brass shell, item 1. The feed-through insulators, 3, are a standard commercial item. Pin receptacles, 4, are made from beryllium-copper rod which has been drilled, slit and silver-plated.

In assembly, the metal insert, 2, is placed in the shell to locate the terminals while they are being soldered to the shell. Items 3 and 4 are assembled and inserted into items 1 and 2 along with the appropriate solder rings as shown.

The entire assembly, 7, is preheated and then immersed, with the aid of appropriate jigs, in a bath of Crisco for approximately 30 seconds at a temperature of 550 F.

The socket terminals are sufficiently flexible to account for pin location variations from tube to tube. This is accomplished by slitting the terminal and by using a flexible lead-through insulator. The magnitude of the connector displacement is limited by the polystyrene spacer, 5. In assembly, the split ring, 6, is held tightly in the groove around the circumference of the spacer. The spacer and ring are inserted in the socket and, when seated, the ring expands into a groove in the shell.

The miniature sockets are assembled similarly except for a center shield pin screwed into the shell.

Plug-in Components

Certain electronic circuits and devices are most usefully constructed in the form of separate, hermetically sealed components which may be plugged into larger assemblies. Figure 3 illustrates a hermetically sealed plug-in oscillator tuner circuit. This circuit is plugged into a hermetically sealed octal socket so that it may be removed from the larger unit without affecting its seal. The components of the tuned circuit are vacuum potted in a can with a hermetically sealed header. The potting process is used primarily for mechanical strength since potting, by itself, does not form a satisfactory hermetic seal. The assembly is fastened to the larger units by screws through the two lugs. The screws fit into sealed studs.

Figure 4 shows an entire electronic subassembly which, in turn, is plugged into a larger unit which may or may not be hermetically sealed. Coil assemblies, tubes and

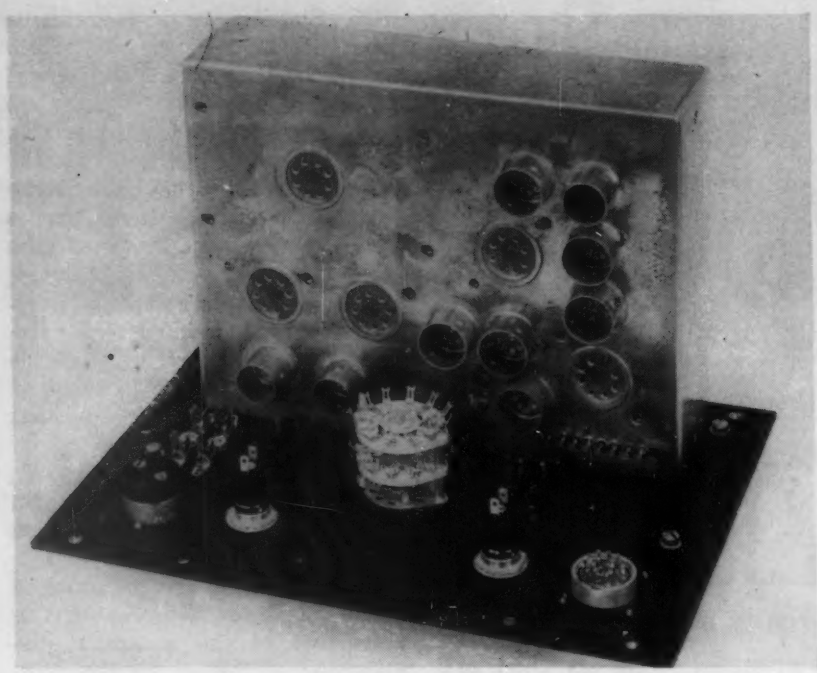


FIG. 5—Complete chassis before wiring. Connections to all major components are made through octal sockets

other sealed components which may require replacement are connected to the subassembly by means of the hermetically sealed sockets. The assembly is connected to the main unit through an hermetically sealed connector.

In case of failure, aside from tubes, coil assemblies, or similar plug-in units, the entire subassembly is replaced by a new unit. Thus, special packaging of spare units is avoided, and the circuit in the subassembly can usually be tested by relatively simple, perhaps plug-in, test equipment.

Hygrometer Indicator

It has been found desirable to incorporate an electric hygrometer in large assemblies involving many solder seals. It is also useful for preproduction tests of smaller subassemblies.

The hygrometer unit is installed inside the assembly to be sealed. One of its terminals is connected to the chassis ground while the other is connected to a lead-through sealed terminal. The hygrometer is used to check the drying process and, in larger units, further permits easy checking of the seal during the life of the assembly.

A relative humidity of six percent, measured at 130 F, results in satisfactory operation of most electronic equipment, as far as condensed moisture is concerned, when the equipment is operated at temperatures as low as −60 F. Consequently, commercial hygrometers have been chosen to operate over the relative humidity range of five to ten percent.

An electronic chassis comprising a test set for other electronic equipment will be described to illustrate the use of hermetically sealed components in a large assembly. All components except low-impedance circuits and power switches are mounted in a standard chassis box which is hermetically sealed.

With all top components removed from the chassis (Fig. 5), it is evident that construction is quite different from usual. The transformer leads are fed through an hermetically sealed octal socket and the transformer is fastened to the chassis with the aid of screws and hermetically sealed studs. Similar mountings are used for the relay, the electrolytic capacitor and the tuned circuits. Low-impedance and power leads are fed through the sealed lead-through terminals. The remaining sockets are for tubes and are also hermetically sealed.

All components are soldered into place before final assembly by solder rings and cylindrical soldering irons.

Resistor boards are fastened to the walls of the main assembly and held in place by rivets which are peened so as to fill an indentation in the assembly wall around the rivet hole. The rivet is soldered to the assembly wall so that a smooth exterior assembly wall surface is obtained. A hygrometer unit is permanently mounted in a corner of the chassis. Final sealing, except for two 1/32-inch diameter holes in the side walls of the chassis, is accomplished by placing a flat metal plate over the bottom of the chassis and flowing solder around its edge in contact with the chassis lip.

Sealing Procedure

As would be expected, it is necessary to dry out the interior of the chassis before making the final seal. The metallic surfaces, and some component surfaces, are covered by an adsorbed layer of water vapor which must also be removed.

In drying a chassis before final sealing, the entire chassis is placed in a heater where it is maintained at a temperature of 130 F for about thirty minutes. Dry air from a commercial air-drying unit is then forced into the chassis through one of the 1/32-inch holes left in the chassis sidewalls. This flushing process is continued until the hygrometer has indicated a relative humidity of six percent or less for at least one-half hour. At this time the two 1/32-inch holes are solder closed while the chassis remains in the drying oven. The sealing process is then complete.

This type of construction should be of use in geophysical prospecting, airborne and many other services where electronic devices are subjected to humid atmospheres, fungus growth and other deleterious conditions.

We wish to acknowledge the assistance rendered in this work by Dr. F. W. Dunmore of the National Bureau of Standards who so kindly furnished information concerning the procurement of suitable hygrometers. Professor E. R. Queer of the Pennsylvania State College Engineering Experiment Station contributed many helpful suggestions concerning proper methods of hermetic sealing and dehumidifying.

Road-Testing Gasoline

Electronic spark-advance indicator and tachometer provide a method of rating gasoline throughout the entire speed range, instead of at two speeds as is usually done in octane number determination

By R. R. PROCTOR

Research & Development Laboratories
The Pure Oil Company
Northfield, Illinois

THE OCTANE NUMBER or octane rating of automotive fuels has for years been determined on what is known as the CFR (Cooperative Fuel Research) engine, a single-cylinder variable-compression-ratio engine running at a slow speed, 600 rpm for the so-called Research Method and 900 rpm for the Motor Method. While this procedure is still standard in all laboratories, it does not give a complete picture of the fuel since rating is determined at only two points or speeds.

About 1936 or 1937 a supplementary procedure known as the Borderline Method of fuel rating was developed by means of which the octane rating of a fuel throughout the entire speed range could be determined. Briefly, the fuel rating is determined by plotting a framework of reference fuels and superimposing the unknown fuel on the framework to determine its octane rating at any speed.

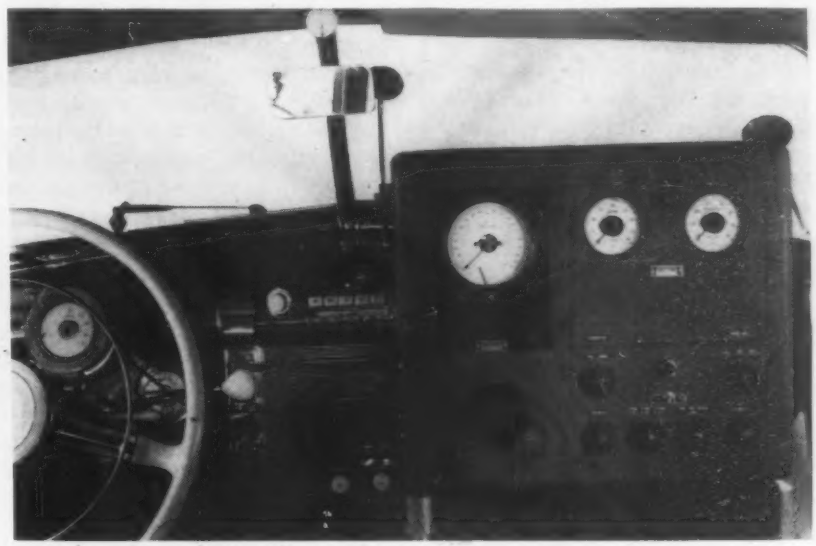
All fuels are used in a test car in which the distributor governor and vacuum advance have been locked out and a manual control installed. The distributor is first set so that ignition occurs at a known point somewhere near top-dead-center of the piston stroke. With the car in high gear and running at 8 to 10 mph on a level road, it is accelerated at wide-open throttle and the speed of the engine at which the knock fades out is recorded. At least two check runs are made, or more if necessary, until the same fade-out speed is agreed upon by two observers. The spark is then advanced two degrees and the procedure repeated, then two more degrees, and so on, until a complete curve has been plotted for speeds up to 70 miles per hour.

A graph consisting of a framework of five or six standard-reference fuels of known octane numbers is thus prepared and the curve of the unknown fuel can be plotted. From a comparison of curves the octane number of the unknown fuel at any speed can be obtained.

Some sort of instrumentation is required to determine the spark advance each time it is changed, or conversely, to set the spark at any given point accurately and easily. Also, since it is easier to work with engine rpm than with miles per hour, and since the standard speedometer is not ordinarily accurate enough for this type of work anyway, an engine-rpm indicator is desirable.

It is necessary to know how far from top-dead-center the spark plugs fire, in degrees of crankshaft movement, and arbitrary limits of 60-degrees advance and 10-degrees retard can be assumed. A stroboscopic light can be used as an indicator but this is rather inconvenient when the driver or observer in the test car must know the spark-advance setting accurately while speeding down the road on a fuel test. Therefore, to bring the indication to the driver's seat, electronics is employed.

To get a reference point electrically, a magnetic pickup is fixed on the engine in such a position that small metal studs on the flywheel pass close to it and produce voltage



Mounted with other instruments in the test car, the electronic unit indicates engine speed and spark advance

pulses in the pickup coil two or three times per revolution. The arrangement is shown in Fig. 1. The pickup is a small reluctance generator consisting essentially of an Alnico magnet in a structure containing a ¼-inch air gap, and a 1,000 to 1,500-ohm coil. The signal from the pickup is conducted to the interior of the car by a shielded wire.

The variable parameter in this problem is the ignition impulse and this is obtained from the ignition primary on the distributor. For a constant engine speed, therefore, two minute pulses of voltage are available in the car, the time interval between which varies as the ignition is advanced or retarded. These voltages are both amplified to give 3 to 4-volt pulses at the output.

A thyratron, *A*, is set up as in Fig. 2, so that when it passes current it will indicate on a meter in its cathode circuit. The circuit constants are adjusted so that the tube is cut off and no current passes unless the grid is made a volt or two positive. The output pulse from the pickup amplifier tube then permits thyratron *A* to fire. Since the plate supply for the thyratron is d-c, the grid loses control after firing and current passes continuously through the meter. The only practical way it can be stopped is by reducing the plate voltage to less than about 15 volts with respect to the cathode. To do this another thyratron, *B*, which draws plate current through the same plate resistor as thyratron *A*, is fired by the amplified voltage pulse from the ignition primary.

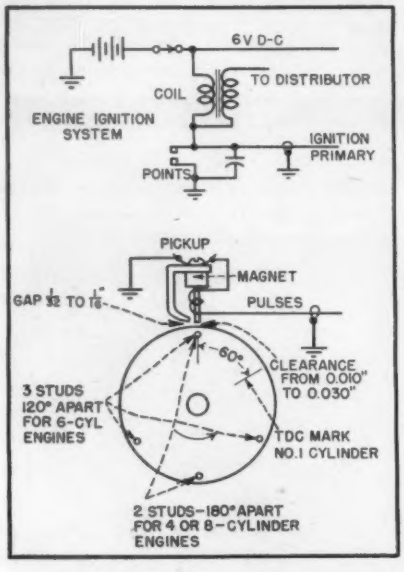


FIG. 1—Location of flywheel pickup-studs for 4, 6 and 8-cylinder engines, and electrical circuits used to actuate the electronic equipment

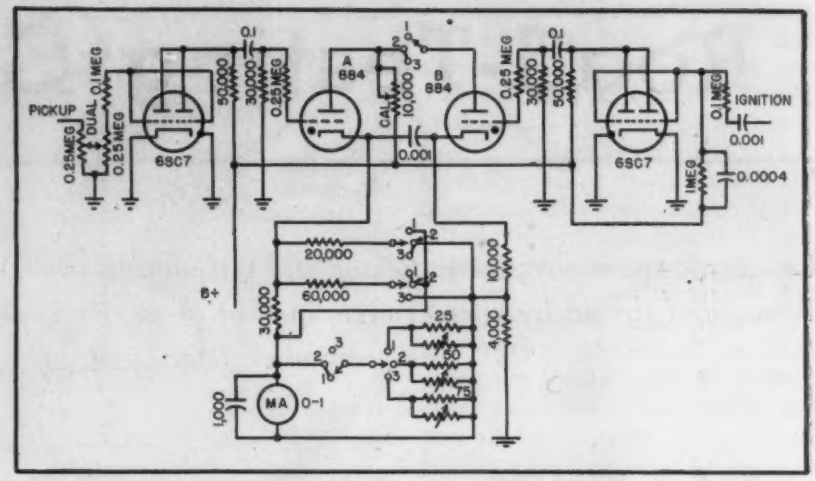


FIG. 2—Circuit for showing how far from top-dead-center the plugs fire

As thyratron *B* fires, the voltage drop across the common plate resistor increases suddenly, thus greatly reducing the plate voltage of thyratron *A*. At the same time, by means of a small capacitor connected between *A* and *B* cathodes, the cathode of *A* is given a positive pulse when thyratron *B* fires and becomes momentarily positive with respect to the plate. The tube is therefore extinguished and only the thyratron *B* passes current, which does not flow through the meter. Since the meter is no longer passing current, its needle drops back toward the left. And since the grid of thyratron *B* no longer controls, this tube continues to pass current to ground until the next impulse from the pickup amplifier trips thyratron *A* again. This extinguishes thyratron *B* by the process just explained, and current again starts to flow in the meter circuit.

Thus the meter receives current intermittently, and, with a capacitor across it, will indicate average current which is dependent in value on the ratio of the on-time to the off-time of thyratron *A*. This ratio is constant at any speed of the engine flywheel as long as the ignition timing or spark-advance setting is constant.

When the spark setting changes, the ratio changes accordingly. Hence, the magnetic pickup is installed in such a way that a flywheel stud passes it and produces a pulse 60 degrees before top-dead-center on the No. 1 cylinder. Theoretically, spark advance from plus 60 to minus 60 degrees can be indicated on a meter with a zero-center scale. When the ignition is advanced to 60 degrees before top-dead-center, the ratio of on-time to off-time is theoretically one over infinity, or zero, and both thyratrons fire almost simultaneously. Thyratron *A* cannot remain ignited for more than an instant and hence it will pass practically no current. The meter, therefore, indicates almost zero current, so the bottom of the scale is marked 60-DEGREES ADVANCE.

Since we seldom are interested in more than 10-degrees retard, 10 DEGREES RETARD is made the top point on the scale and the meter is caused to read full current for this setting by juggling the series and shunt resistors. Now, using one pin on the flywheel, and with the ignition at say, 40 degrees before top-dead-center, the ratio of on-time to off-time is 40 degrees out of 360 degrees or 1 to 8, the pickup thyratron fires 60 minus 40 or 20 degrees before the ignition primary thyratron and the meter passes current for a certain period. The pulses are averaged and this average current point is marked 40-DEGREES ADVANCE. At top-dead-center, for example, the ratio of on-time to off-time is 60 degrees out of 360 degrees or 1 to 5, the meter reads still higher and this point is marked ZERO DEGREES. Thus the meter is calibrated from

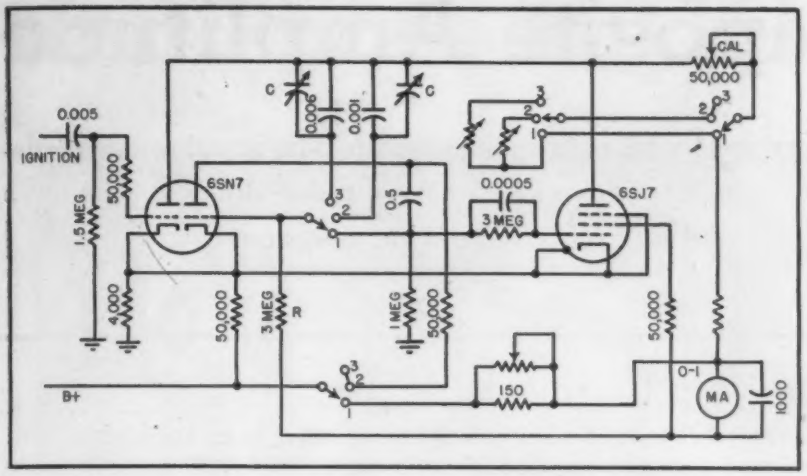


FIG. 3—Tachometer circuit for measuring engine speed

minus 10 degrees on the right to plus 60 degrees on the left, and the spark setting at any time can be read instantaneously on this meter.

With a constant voltage source for the plates, obtained from a vibrator and rectifier system operating on the 6-volt car supply, the instrument described indicates the spark setting at all times, inside the car.

Speed Measurement

Additional tubes integrate the ignition primary impulses and indicate them as average current on another meter calibrated in rpm to provide an electronic tachometer. The tachometer circuit is shown in Fig. 3.

The ignition impulse applied to the grid of one triode of the 6SN7 causes that triode to draw current through the meter and its series resistors. This applies a negative pulse to the grid of the other triode through one of the mica coupling capacitors, the capacitance of which determines the range. (Two scales are sometimes used, 0-1,000 and 0-5,000 rpm.) This pulse is amplified and applied to the grid of the 6SJ7, causing this tube also to draw current through the meter and its series resistors. The action is cumulative, resulting in a final current in the 6SJ7 limited only by the series resistors in the meter circuit. This current flows without change until the charge leaks off the mica coupling capacitor and the circuit returns to its original state with the 6SJ7 cut off. At this time, the second half of the 6SN7 is again drawing full plate current.

The meter reads average current, which is quantity-per-unit-of-time, or engine speed. Resistor R and the mica coupling capacitors, with their adjusting trimmers C, determine the time of flow, which must be less than the time between impulses at the highest speed to be measured. For this circuit the time of current flow is approximately 0.7 RC second.

The complete instrument requires but two wires to a battery and two wires to the engine to give all the information needed in the test. Calibration can be made accurate to plus or minus 1 percent in speed and plus or minus 1 degree in spark advance at any speed or spark setting and under battery-voltage variations from 5.5 to 7.5 volts.

Other Details

On a 6-cylinder engine, 3 pickup studs on the flywheel provide three pickup impulses per revolution. This tripling of the current impulses to the meter allows decreasing the instantaneous load on the B supply and reducing the size of the capacitor across the meter. On an 8-cylinder car, four ignition impulses per revolution are obtained. Theoretically four studs on the flywheel could be used since the 70-degree range is less than 360/4 or 90 degrees, but practically it is rather difficult to get four pins exactly 90 degrees apart on the flywheel. Hence 2 pins 180 degrees apart are used. In this case there is provided a pickup impulse, then 2 ignition impulses, before the next pickup pulse. The second ignition pulse has no effect, however, as thyratron B is already passing current, having been tripped by the first impulse.

The total current through the meter is less than in the case of 3-stud 6-cylinder operation, so the resistor network in the meter circuit must be changed. A selector switch is incorporated in the panel which changes circuit conditions to allow one or two-stud 4-cylinder operation, 3-stud 6-cylinder operation or 2-stud 8-cylinder operation. This same switch also changes the resistors in the tachometer circuit.

A calibrating circuit is also incorporated to allow setting the meter to a definite point (zero degrees on the scale) at any time to compensate for tube aging and other factors. A gain control on the pickup line, and a check position on the calibrating switch permit setting the gain to a standard point without flicking the meter needle to one end or the other.

The B voltage for the instrument is obtained from a vibrator power supply which incorporates a T-4½ neon lamp, a 6SJ7 and a 6V6 connected in the usual voltage-regulator circuit. The load on the unit is very nearly constant and the input voltage is the main variable. The output voltage supplied to the tubes is nominally held to less than one-percent change for 20 percent or more change in input voltage.

The original circuits were designed around 1-ma fan-shaped meters. Several instruments have been built recently, however, using 2-ma or 5-ma concentric-scale meters, such as shown in the photograph. The basic circuits have necessarily been changed somewhat to accommodate the higher current, but the advantages of the longer easier-to-read scales more than offset the circuit complications involved.

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Composite Amplitude

High transmitter efficiency is combined with reduced bandwidth. The signal to one modulator is shifted 90 degrees. This, plus the inherent 90-degree phase difference between sidebands from p-m and a-m, cancels one set of sidebands

By

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A SYSTEM OF CARRIER MODULATION having several unique advantages compared with conventional double-sideband amplitude modulation has been developed. Although this new method produces substantially a single-sideband with carrier, the signal can be demodulated with negligible distortion in conventional receivers employing linear diode detectors. The bandwidth required for transmission is approximately half that of the double-sideband method. The maximum amplitude modulation required for communication, equally effective to that obtained with 100-percent double-sideband a-m, is 81.5 percent, resulting in a saving of 33 percent in audio power when plate modulation is used.

The system can be added to existing phase or amplitude modulated transmitters with very little trouble, and appears to be the simplest way to achieve the advantages of single-sideband transmission from the standpoint of simplicity in installation, adjustment and maintenance. The sole disadvantage of the system is the presence of an appreciable second-order sideband that is beyond the primary sideband and is capable of causing adjacent-channel interference comparable to that arising from a badly adjusted conventional transmitter. It should, therefore, be particularly interesting for low-power mobile and point-to-point communication where moderate adjacent-channel interference can be tolerated, as in Fig. 1.

Basically, the system consists of combined amplitude and phase modulation with a 90-degree phase shift between the two audio modulating voltages. Because a-m and first order p-m sidebands are in radio-frequency quadrature, this arrangement can be made to cancel either the two upper or the two lower sidebands, as in the phase-rotation system of single-sideband modulation.

Sideband Structure

Operation of the composite system will be more readily understood after a description of its sideband structure for a single-frequency modulating voltage. The first problem is to select the degree of modulation for which the composite system will have a communication effectiveness equal to that of a carrier wave 100 percent amplitude modulated. It is necessary that the uncancelled first-order sidebands have a combined amplitude seven-tenths that of the reference carrier. This requirement arises because the receiver bandwidth is halved with the new system, hence the noise power received is halved. Because the two sidebands in a-m add directly, so far as detection is concerned, removing one has the same effect as cutting the sideband power to one-quarter its former value. Thus, for the remaining sideband power to be halved (that is, reduced as much as is the noise power when the receiver bandwidth is halved), the remaining sideband must have 0.707 times the reference carrier amplitude.

In the composite system, half of this sideband (35 percent) is contributed by a-m, and half by p-m. Assume that 3,000-cycle p-m alone is acting on the carrier; an index of 0.75 radian is sufficient to give first-order sidebands of 0.35 times the reference amplitude. The resulting spectrum (amplitude vs frequency) is illustrated in Fig. 2A. If this phase-modulated radio wave is simultaneously amplitude-modulated 81.5 percent by a 300-cycle tone, the spectrum becomes that of Fig. 2B. It will be observed that a pair of a-m sidebands (shown with dotted lines for clarity) is generated about each component of the original p-m spectrum. The low frequency of the second modulation helps to make the situation clear. Note that the entire wave must be amplitude-modulated 81.5 percent in order to generate two sidebands on either side of the reduced carrier of 0.35, or the same amplitude as the first-order p-m sidebands.

Components Combine

We may now re-examine the spectrum when the a-m frequency becomes relatively high, say 2,900 cycles, illustrated in Fig. 2C. This representation of the sidebands shows what happens when the frequencies producing the a-m and the p-m become the same. The groups of sidebands merge, and the resultant sideband at each 3,000-cycle interval can be found by combining the components, taking the various phase relationships of each component into account.

Figure 2D shows the original p-m spectrum but with the relative phases of the components indicated by the direction of the vectors, for the instant at which the modulating voltage passes through a maximum.

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and Phase Modulation

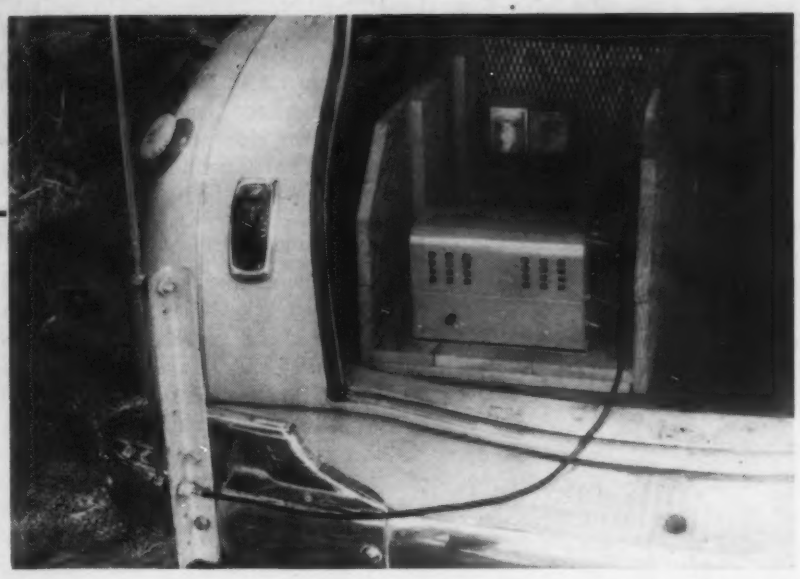

FIG. 1—Mobile single-sideband transmitter used by author to test dependability of unconventional modulation system that produces a signal which is easily demodulated by a conventional receiver

Figure 2E shows this spectrum with the addition of a-m sidebands corresponding to an audio voltage 90 degrees out of phase with that producing the p-m; however, for the sake of clarity these sidebands have been shown displaced from their correct position in the frequency spectrum. In Fig. 2F, the sidebands are given their correct position and phase, so that their resultant can be found. The final spectrum, phases once more disregarded, appears in Fig. 2G.

It will be seen that the first-order sidebands on one side of the carrier are nearly cancelled (cancellation can be made complete by a slight reduction in the percent a-m), while those on the other side add directly. Of particular interest is the relatively strong second-order sideband (0.22) on the same side of the carrier. The remaining higher order sidebands are negligible, being 20 db or more below the desired first-order sideband.

Modulation Distortion

The existence of a strong second-order sideband in the composite modulating system is not surprising when it is remembered that the envelope must necessarily be sinusoidal when all frequency components are taken into account. This must be the case since the shape of the envelope is solely due to the a-m portion of the composite modulation. If the carrier and the first-order sideband were taken by themselves, their envelope would be distorted, rather than a pure sinusoid. (For example, if carrier and sideband were equal in strength, their envelope would resemble the output of a full-wave rectifier.) It follows that the strong second-order sideband has the effect of removing a large portion of the envelope distortion which would otherwise be present. Because the other sideband components are 10 db or more weaker than the strong second-order sideband, it seems safe to assume that the envelope will be very nearly sinusoidal even when these components are neglected.

It is interesting to observe that when a true carrier-plus-single-sideband signal in which the ratio of sideband to carrier is 0.7 to 0.86, as in the situation under discussion, is rectified in a linear detector, the second harmonic distortion in the output is 18 percent. This is of the same order of magnitude as the audio signal which would be produced by the rectification of a carrier of 0.86 and a second-order sideband of 0.22.

It therefore appears that when, in the composite system, only the carrier, first-order sideband and strong second-order sideband are accepted by a selective receiver or band-pass filter, the resulting signal will have an envelope substantially free from distortion.

Furthermore the distortion will be low at all modulation levels. While the p-m portion of the second-order sidebands will decrease faster than the modulation level, thus tending to remove the difference between these sidebands at low signal levels, at the same time the distortion accompanying linear detection of a single first-order sideband tends to decrease as the modulation depth decreases. Thus the distortion (and the level of the spurious higher-order sidebands as well) will never exceed the full modulation situation illustrated in Fig. 2G.

We may now consider a typical example. Assume a voice communication system having a maximum modulating frequency of 3,000 cycles. A receiver having a 3,000-cycle bandwidth and a linear diode detector can be tuned so that the carrier falls at the proper edge of the passband. For all modulating frequencies below 1,500 cycles, the strong second-order sideband falls within the receiver passband, and detection is substantially distortionless. For modulating frequencies between 1,500 and 3,000 cycles, the second-order sideband will fall outside the receiver passband, and detection will be accompanied by roughly 18-percent distortion.

As far as adjacent-channel interference is concerned, there will be a band of frequencies 3,000 cycles wide outside the 3,000-cycle bandwidth of the system in which spurious sidebands will be heard of an amplitude equal to that which would be present if the radio wave were amplitude-modulated in the

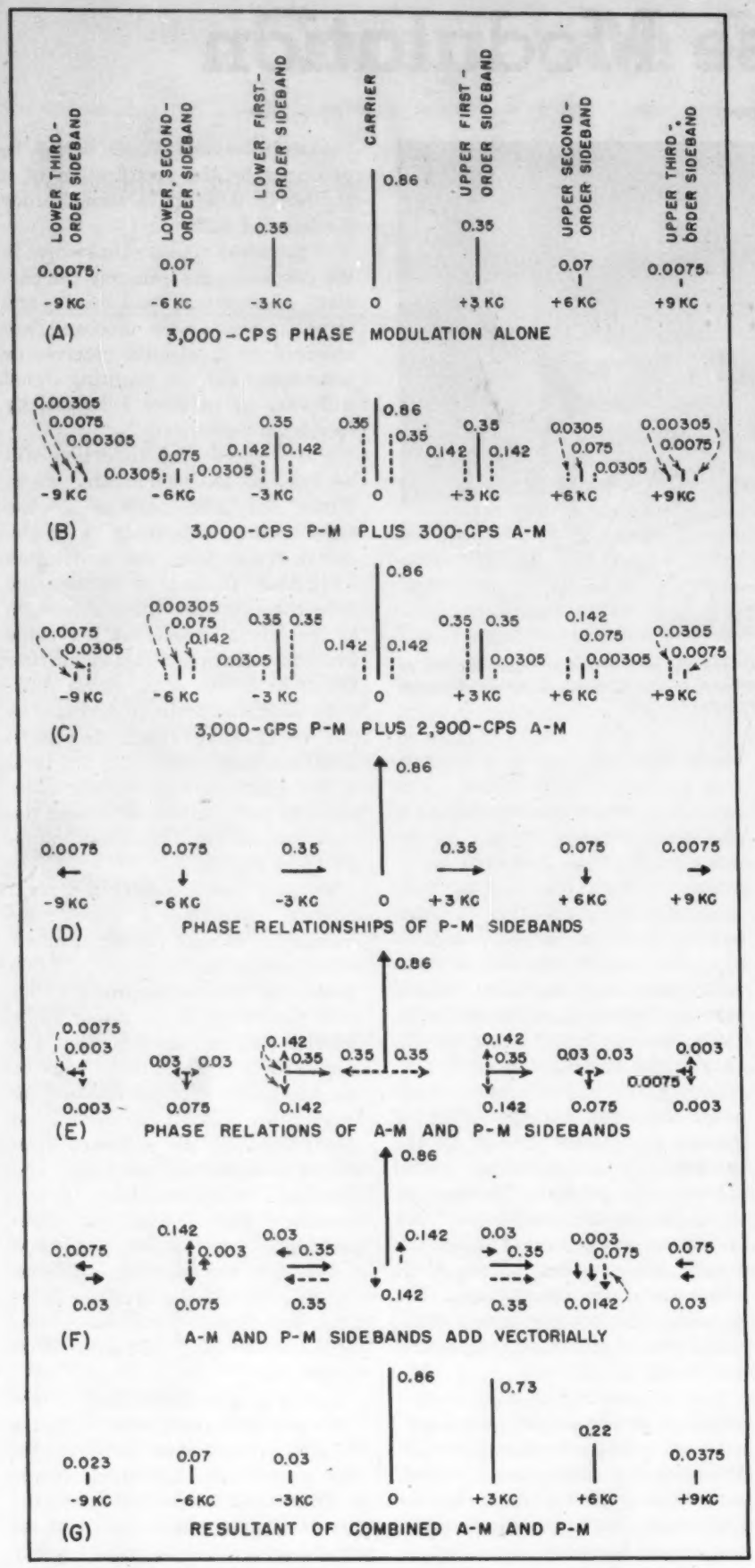

FIG. 2—Type of transmitted signal produced by composite modulation can be visualized from the sidebands produced by it. Signals shown are not to scale

conventional way with a signal containing approximately 45-percent second-harmonic distortion. In estimating the practical effect of this interference, it should be remembered that the strongest and most often-occurring frequency components in speech or music are in the range below 1,500 cycles, where the sidebands fall within the assigned channel and negligible distortion occurs in reception.

Adjusting the Modulators

The combined modulation system has been tried both in the laboratory and in several experimental transmitters. Its installation involves one unusual feature, which is a phase-equalizing network. The purpose of this network is to make the frequency response of the phase modulator, and of any associated amplifiers, identical to that of the amplitude modulator and its associated amplifiers. This is essential if the 90-degree phase shift existing at the output terminals of the phase-shift network is to be preserved through to the voltages which actually perform the phase and the amplitude modulation. Any difference between the shapes of the frequency response curves of the two modulator channels will introduce a spurious phase shift which must be avoided. In most cases it will be found that the frequency response of the amplitude modulator is worse than that of the phase modulator, owing to the presence in the former of driver and modulation transformers.

The required equalization can then be obtained by inserting simple single-section R-C high-pass and low-pass filters in the audio line to the phase modulator. It is convenient to make the resistances variable and to find the correct values experimentally with the aid of an oscilloscope connected to show the phase shift between the voltages actually performing the phase and the amplitude modulation. The leads normally connected to the two outputs of the 90-degree phase-shift network are connected in parallel and to the terminals of an audio oscillator. If the 45-degree line on the oscilloscope opens into an ellipse at any frequency, undesired phase shift is present. The

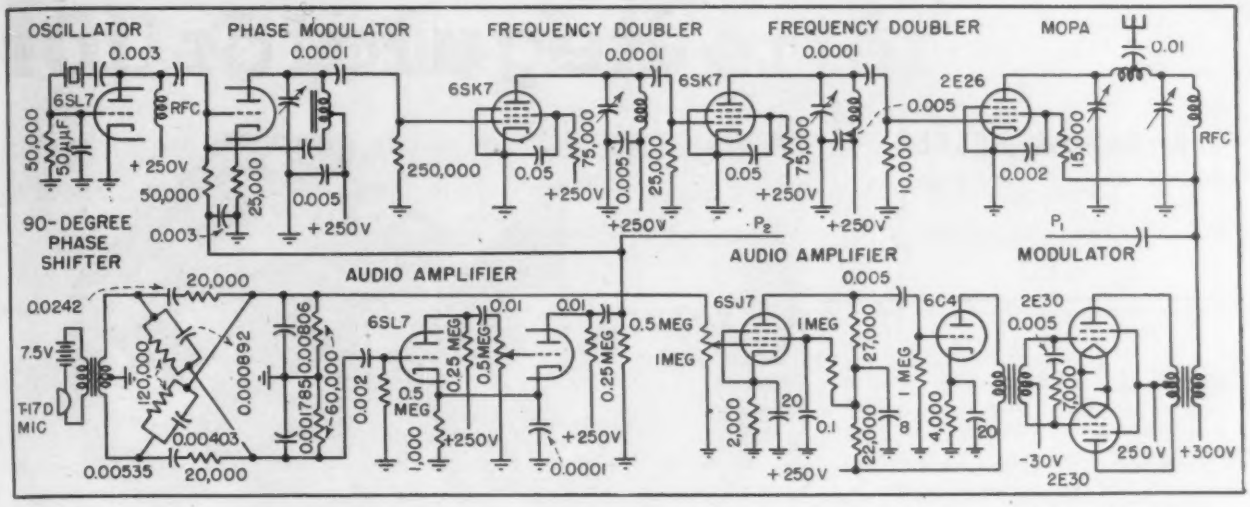

FIG. 3—Principal circuits of mobile transmitter using composite modulation. Values of unlabeled parts depend on carrier frequency

correct adjustment of the equalizing network is surprisingly easy to find in practice, even when widely different phase and amplitude modulators are used. It is theoretically possible that filters having two or more sections with differing time constants might be needed if the amplitude modulator has many stages compared with the phase modulator. In the cases tried so far, single-section filters have been sufficient.

The phase modulation index for optimum sideband cancellation is readily found with the aid of a selective receiver, preferably one having a crystal filter. A sine wave in the 2,000- to 3,000-cycle range is applied to the amplitude modulator, and the percent modulation adjusted to 81.5. The receiver is then tuned to the unwanted sideband and the gain of the phase modulator adjusted until cancellation occurs.

Note that only *one* adjustment (relative phase modulator gain) is required. There is no simultaneous radio-frequency phase setting to be made, nor are there any balanced modulators whose characteristics must be equalized, as in other phase-rotation single-sideband systems.

Cancellation of the undesired sideband with the composite system is readily detectable in practice, even with a fairly unselective receiver. Receiving operators are seldom aware of the nature of the incoming signal, since it sounds like any other; they automatically tune slightly to one side of the incoming carrier to make the modulation sound the loudest. Reversal of the phase of the voltage fed to one modulator will cause the opposite sideband to be cancelled; the receiving operator then finds he must tune to the opposite side of the carrier for loudest modulation. Another interesting demonstration is to ask the receiving operator to narrow his bandwidth and tune in the composite signal for best reception. If the phase modulator is then disabled, the receiving operator will report a noticeable drop in the strength of the modulation.

Circuit Details

To illustrate the stability and reliability of the composite system, the author installed a mobile single-sideband transmitter in the trunk compartment of his car. After 4,000 miles of vacation driving, some of it over unpaved roads in national parks, the transmitter was checked and found to be in perfect adjustment, having given satisfactory performance throughout the trip.

A simplified circuit diagram of this transmitter is shown in Fig. 3, and a photograph of the installation appears at the beginning of this article. The 90-degree audio phase shift is obtained from a network driven directly by a surplus T-17D carbon microphone. This microphone also serves very conveniently as a band-pass filter, its output being restricted to those frequencies (300–3,000 cycles) for which the phase-shift network is effective. The stepup transformer between the microphone and the network should not have too high a turns ratio; the conventional variety will not maintain a 180-degree phase shift between halves of the secondary at all frequencies, owing to the finite input impedance of the network. Small power-output transformers of the type designed to match push-pull tubes (20,000-ohms plate-to-plate) to a 200-ohm line have been found to be satisfactory.

The transmitter itself consists of a commercial phase-modulated unit which has been modified for simultaneous amplitude modulation. The final stage was rewired to permit simultaneous plate and screen modulation, and a smaller screen bypass capacitor inserted. No other changes were needed. The amplitude modulator is conventional. In this particular arrangement, the only phase equalization found to be necessary was the 0.002-μf capacitor in series with the line to the phase modulator audio input. This was determined by connecting an oscilloscope to the points marked P_1 and P_2 and following the procedure outlined earlier.

Research, the result of which is described in this paper, was an outgrowth of Project W-28-099-Ac-131 between Stanford University and the Watson Laboratories of the Air Materiel Command. The author wishes to thank the Watson Laboratories for their cooperation and for permission to publish this paper.

Regulator for

By CARL A. HELBER

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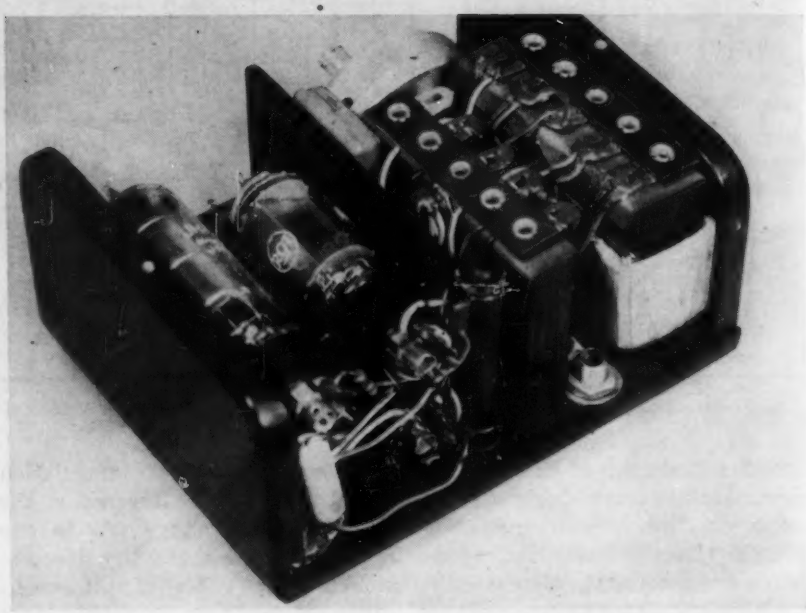

The entire regulator is packaged to fit into a space of 4¼ by 3½ by 2 inches high

NUMEROUS methods have been used for regulation of aircraft inverters. Among them are the carbon pile, Tirrill vibrating contact, Brown-Bovari, Silverstat and others. In each of these systems there are some moving parts which are subject to mechanical wear.

The electronic regulator to be described compares favorably with the previously mentioned regulators in regard to size, weight, accuracy, reliability and other factors. While the regulator which was developed for use on a 250 volt-ampere machine is somewhat heavier (1.7 lb compared to about 1.1 lb) than the carbon pile regulator, it has the advantage of having no moving parts.

In laboratory tests the unit appeared to be quite reliable for any of the conditions it was designed to meet. The electronic regulator is capable of providing about 40 watts of d-c power to the exciter field in the inverter and maintains the output voltage of the inverter within ±1.0 volt from no load to full load.

Inverter Operation

As shown in the diagram, the inverter is supplied with 28 volts d-c from the aircraft battery and generator. The exciter field current is supplied partly by the 28-volt d-c source to help the machine build up and partly by the rectified a-c from the output of the inverter. Without a-c excitation, the 28-volt supply provides about 30 volts at the output terminals of the inverter at no load.

The field current is governed by the saturable reactor *SR*. As the current through the d-c winding of *SR* is increased, the reactance decreases. This action increases the amount of excitation provided to the machine. By adjusting this current to the proper value, the output of the machine can be maintained within narrow limits for a wide range of load conditions.

Tube Circuit

Most voltage-sensitive circuits provide a rapidly increasing current with a small increase in voltage above some given reference level; this being just the opposite of the characteristic which is desired by the saturating coil of the reactor.. It is therefore necessary to provide a fixed maximum current through the saturating coil of the reactor, this current being bucked by the current provided by the voltage-sensitive circuit. The fixed current is made high enough to provide full output from the regulator when the voltage reference circuit is not supplying any bucking current. The major portion of this current is bucked out by the voltage reference circuit under the condition of lowest field requirement (no load).

The voltage-sensitive circuit, 2D21 and OB2, is designed to provide a sharply increasing current for a slight increase in output voltage. This characteristic is obtained by triggering a thyratron with the voltage drop across a resistor in series with a VR tube. The thyratron is normally a-c biased to a point sufficient to prevent firing. When the voltage drop across resistor R_1 is great enough to overcome the necessary portion of the bias, the thyratron will fire. With the circuit arrangement used, firing occurs at approximately the peak value of the output voltage and therefore the thyratron conducts for about one quarter of a cycle.

Because of the relatively high inductance of the polarizing winding on the saturable core reactor, the pulses of thyratron current are smoothed considerably. The number of these pulses provided to the polarizing coil per second determines the average current flowing in the polarizing coil of the saturable core reactor.

In typical operation, the number of pulses per second may range anywhere from one to four hundred. This current opposes the fixed current provided by resistor R_2. Thus the polarizing coil current may have any average value between the maximum current as provided

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400-Cycle Inverter

Voltage output of an aircraft inverter is maintained within plus or minus one volt from no load to full load by a two-tube electronic regulator having no moving parts. Operation remains substantially constant down to — 55 centigrade

by the battery and a value of zero.

Resistors R_3 and R_4 are used to provide the a-c bias for the 2D21. For economy, resistor R_3 is a potentiometer which is used to adjust the level of the regulator voltage. It was found that the d-c voltage drop across the polarizing coil of the reactor was at times sufficient to fire the 2D21 before the bias had gained sufficient amplitude on the positive half cycle of the a-c voltage. In other words at the instant when the a-c voltage is zero going from the negative half cycle to the positive half cycle, the bias is also zero. Since the voltage drop across the polarizing winding may be about 10 volts, some 2D21's will fire at this potential.

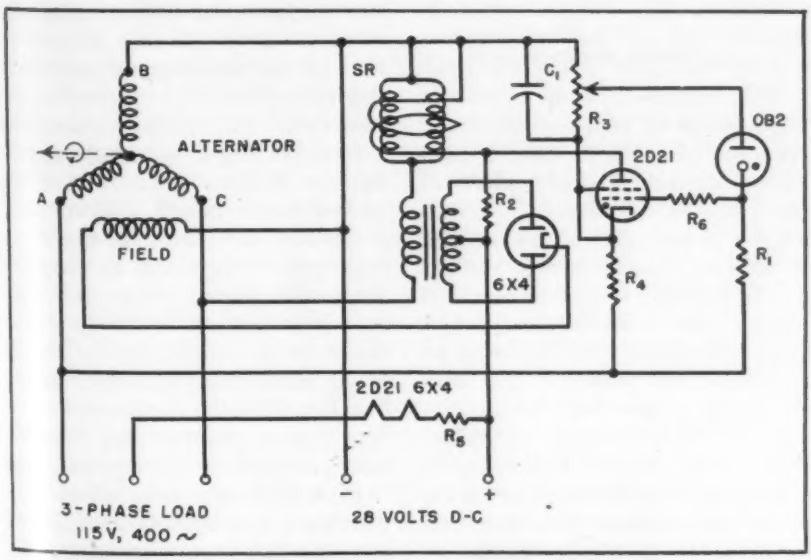
Capacitor C_1 is used to shift the bias a few degrees ahead of the anode voltage in order that the d-c voltage across the polarizing coil will not fire the thyratron. It should be noted that with the constants in the circuit the VR tube fires on the positive half of every cycle. The thyratron may or may not fire on the positive half of each cycle depending upon the magnitude of the peak voltage drop across R_1. This feature makes the firing of the thyratron dependent upon the conduction characteristics of the VR tube rather than upon the striking characteristics.

Since the regulator works on the peaks of the voltage which it is regulating, it is important to maintain a fairly sinusoidal wave form for the output of the machine. Another specification for these machines requires that the waveform be quite good any way so that the regulator does not actually impose any additional hardship on the designer of the machine.

The current supplied to the exciter field ranges from about 70 ma at 105 volts for no load to 150 ma at 225 volts for an output of 250 volt-amperes at a power factor of 0.9 lagging.

The regulator is used on a 3-phase inverter which is designed to provide 250 va of 3-phase power continuously with conservative ratings or 250 va of single-phase power from terminals A and B with the machine running just within ratings. Checks have been made on the operation of the regulator at —55 C and the results indicate that the difference in voltage between this temperature and room temperature is not more than about one volt. Compensation for the variation in exciter field resistance had to be made, however, because of the fact that the field resistance, which is about 1,400 ohms at room temperature, is about 900 ohms at —55 C. A thermistor shunted with the proper value of resistance provides compensation and results in a regulator which is quite satisfactory. Tests at full load were run for 500 hours followed by 150 hours of cycling tests during which the load was changed abruptly from full load to no load in 5-second intervals. The output voltage remained within ±1.5 volts for this entire period. The regulator was still operating satisfactorily when the test was shut down.

It was found necessary to shock mount the regulator to obtain suitable life from the 2D21 thyratron. When mounted directly on an inverter running at 12,000 rpm, the thyratron would last for about 100 hours after which enough cathode material had been broken loose to make the tube characteristics change considerably. It was suspected that the high (200 cps and above) vibration frequencies were responsible for this effect. Proper vibration isolation solved this problem. Regulators based on the same principle have been built for machines up to 2,500 volt-amperes capacity and undoubtedly could be made for much larger machines.



Complete circuit of voltage regulator for a 400-cycle, 250-va aircraft inverter

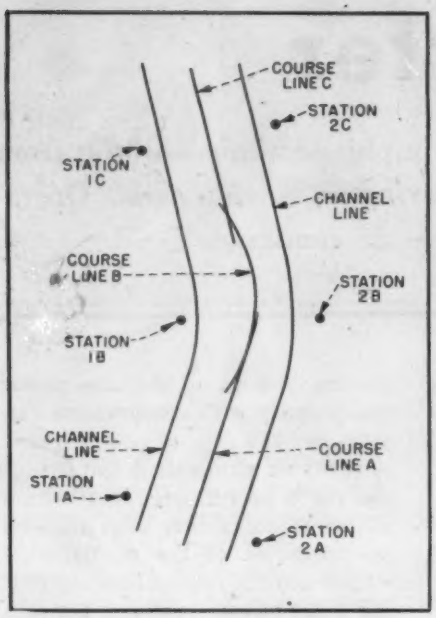


FIG. 1—Transmitter locations along a channel

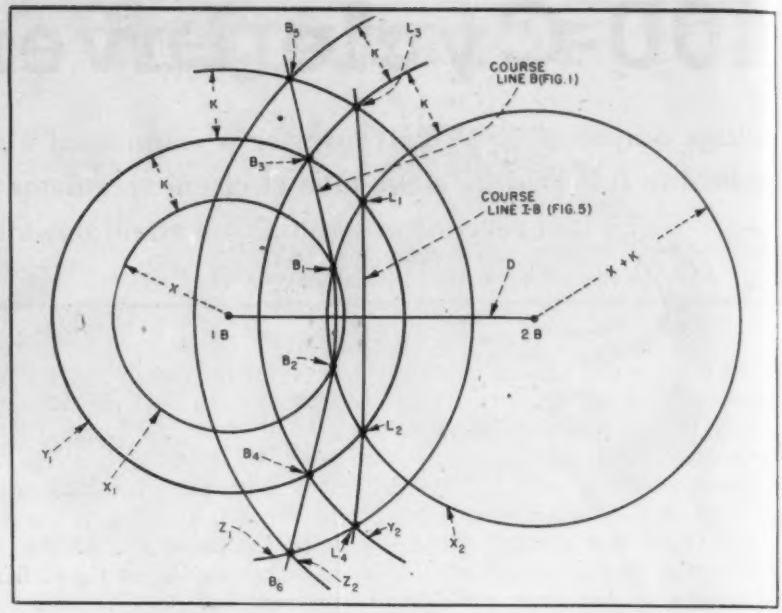


FIG. 2—Construction shows how straight and curved course lines are generated

Sonic Navigation

A new hyperbolic underwater-sound navigation system for harbors and channels uses pairs of transmitters pulsed at audible frequencies. A ship on course receives the two tones simultaneously. Aural monitoring assures position within 50 yards while lesser deviations are possible when meter indications are used

CONVENTIONAL METHODS of harbor navigation require the following of floating buoys in order to keep ships in the proper traffic lanes as well as in channels of safe navigable depth. Pilotage by buoys becomes extremely difficult in fog when neither the buoy nor the light with which it may be equipped is visible for any appreciable distance. Whistling and bell buoys can be followed at best only at a slow rate of speed and then only if all other conditions are quiet. As a result most ships are still forced to wait out a fog rather than risk entering or leaving a fog-bound harbor.

The Hysonav system described below employs underwater sound to mark channels and traffic lanes which can be followed by any vessel having only the simplest listening equipment, independent of weather conditions.

System Elements

The system consists of one or more pairs of underwater sound generators located at spaced positions along a channel or traffic lane, one member of the pair (illustrated) on each side of the channel. In each pair the members are pulsed at intervals, and the pulse from each member has a distinguishing frequency characteristic. A person on a vessel sailing between a pair is in a position to hear both generators with a simple listening or hydrophone arrangement. Pulse lengths as short as 30 milliseconds are used, so that the listener can ascertain his position within fifty yards.

In accordance with the basic concepts of a hyperbolic system, the listener navigates the path on which he receives a single note, indicating that first-arrival signals from both generators are being received simultaneously. This path is made to be a straight line or a curve, depending on channel shape and other harbor requirements. Where it is a straight line, two generators are pulsed simultaneously, so that the locus of points where the first arrival pulses are available simultaneously is a straight line which is the perpendicular bisector of the line between the generators. To provide a curved path, the two generators are pulsed in sequence, and, as explained below, the isotime locus generated is a hyperbola, which is made to fit a particular channel by adjusting the time interval between

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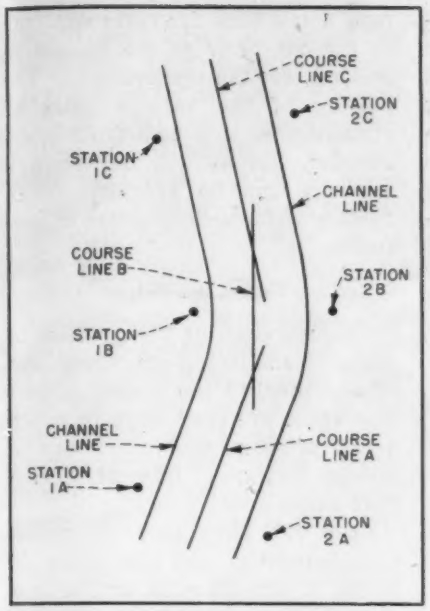

FIG. 3—Curved channel—straight courses

System

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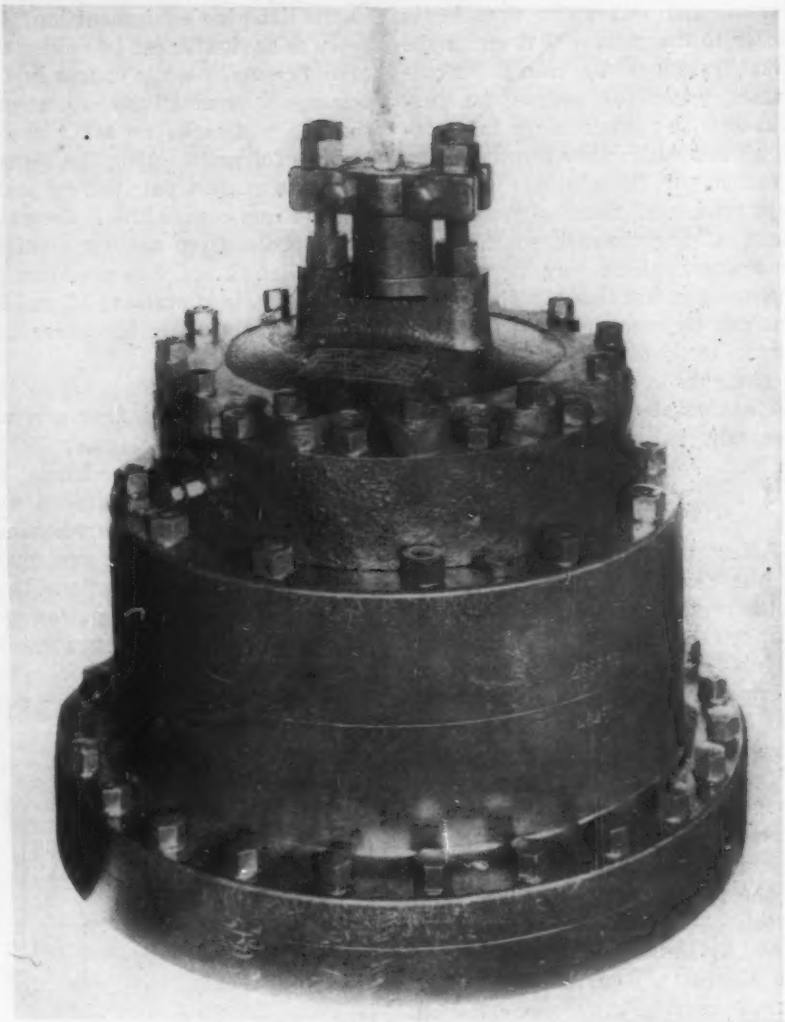

Oscillator transducer used at transmitter stations

the pulses. If the navigator is not on the predetermined path or course, he will hear first one and then the other pulse, and he tells them apart by the difference in audible pitch. In this way he knows which way to turn to regain his course. This information may be used to enable the navigator to keep to one side of a predetermined center line for two-way traffic.

Referring to Fig. 1, a ship channel is illustrated, as delineated by a pair of channel lines. It is desired to provide a system that will guide a vessel along the center line of this channel. A number of pairs of sound generators are located along the channel, the members of each pair being located one on each side. Thus Stations 1A and 2A comprise one pair, 1B and 2B a second pair, and 1C and 2C are a third pair. Stations 1A and 2A are on a straight section of the channel. They are pulsed simultaneously at intervals which, for convenience, are regular. The stations of a pair are distinguished by a difference in the pitch of the respective signals; that is, the frequency of sound emitted by Station 1A is different from that of Station 2A. For example, 1A may oscillate at 600 cycles per second when pulsed, while 2A may oscillate at 900 cycles per second. The stations are so located with respect to the channel that the perpendicular bisector of the straight line drawn between them coincides to a satisfactory degree with the center line of the channel in the region of these stations.

This perpendicular bisector is designed as course line A. It is the locus of points which are equidistant from both stations for sound travelling through the water, so that a person on a vessel which is navigated along this line is in a position to hear a single sound, which is a mixture of 600 and 900 cycles per second, whenever the stations are simultaneously pulsed. Thus, a navigator who is provided with only simple underwater listening equipment needs merely to steer the path along which he hears this single mixed signal to remain in the channel and on course line A in even the deepest fog. If he steers or drifts too far to one side or the other, he will hear a sequence of two pulse signals, either a low and then a higher frequency, or vice versa, each time the two stations are

pulsed, and will know that he is closer to the station that emits the first frequency he hears. Navigators would, of course, be furnished with the necessary information from which they can mark the locations of the stations and the frequencies of their signals on a chart of the channel, so that one may know which way to turn to sail along course line A. The course line can be regarded as a highway center-line, and, when it is desired to navigate to either side, it is useful that the signals are received successively rather than simultaneously.

Curved Channels

After passing along course line A, the channel curves to the left, in the region of stations 1B and 2B. Stations 1B and 2B are pulsed in such a fashion that the locus of all points at which the emitted pulses will be heard simultaneously is a curved line which follows the curve in the channel to a satisfactory degree. This line is designated as course line B in Fig. 1. Course line B is curved by pulsing one station of the pair before the other. The direction of curvature is determined by the order of pulsing, and the degree of curvature by the amount of time difference between the pulsing of the first and second stations. In Fig. 1, course line B is curved to the left by pulsing station 2B prior to station 1B.

Station 1B emits signals having the same sound frequency as those of 1A, while 2B emits signals having the same sound frequency as those of 2A. As the navigator leaves Stations 1A and 2A behind and approaches 1B and 2B, the signals from the former fade and those from the latter become louder. Where the two paths cross, both pairs of stations will be heard, and a choice of paths may be presented to the navigator. Before he has gone far, the signals from Station A will become weak enough and those from Station B strong enough that there will be no doubt by which to be guided. The signal strengths of the pairs of stations are so adjusted that there is not a strong set of signals tending to guide the navigator out of the channel; that is, course line A fades out in the listening equipment long before the navigator can be guided out of the channel, while course line B becomes comparatively so strong that he will make no other choice than to follow it. Also, the signals from the nearest pair will be heard first. From course line B the navigator proceeds to another straight course line C, which is produced by the third pair of stations 1C and 2C in the same fashion as course line A.

The signals that are heard by the navigator consist of first arrivals plus reverberation signals. The first arrivals are the signals by which the navigator is guided, the reverberations being ignored. Since the first arrival signals are much louder than the reverberations, that is not difficult. Also the pulse repetition frequency of the generators is made deliberately low (ten seconds between pulses). This permits ample time for reverberations to die out prior to the successive pulsing of the generators. The pulsing of the various pairs of stations need have no definite interrelation, but as will be shown a sequence can be provided which further reduces the chances of confusion.

Timing the Pulses

Consideration of the problem of planning and laying out course lines in a channel in the system reveals that there are four ways in which a pair of sound generators may be treated that are of interest. These four cases are:

Case 1. They may be pulsed simultaneously, and the locus of points of simultaneous arrival is a straight line which is the perpendicular bisector of the line between them (course line A).

Case 2. They may be pulsed in

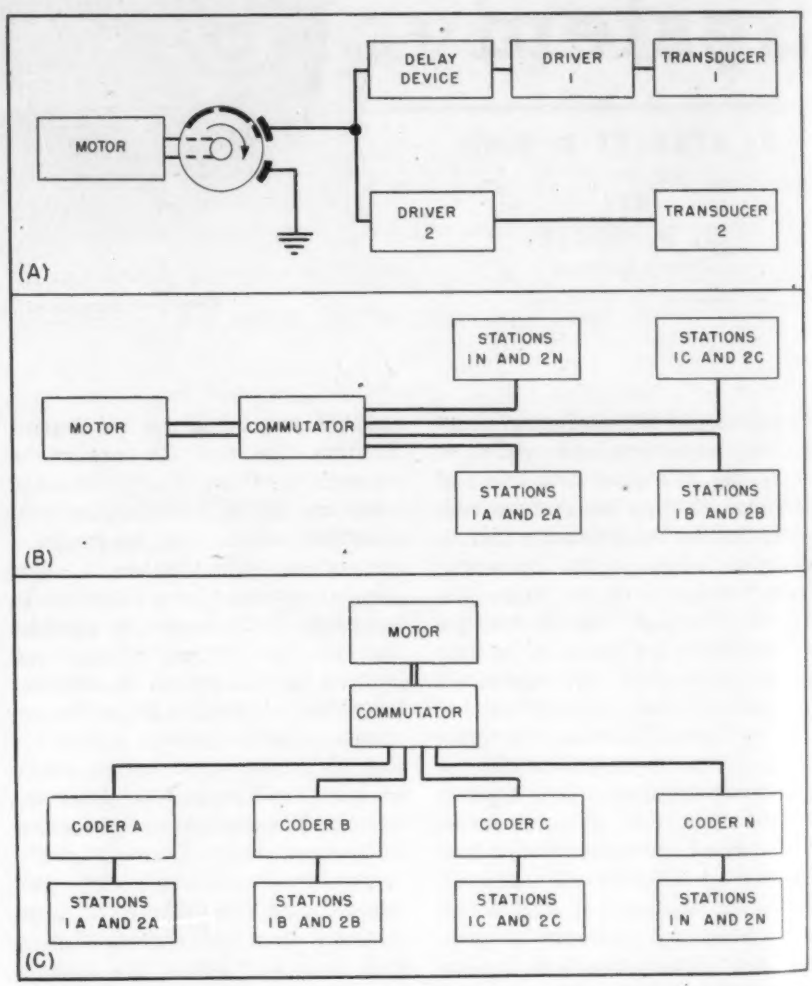

FIG. 4—Development of keying and coding methods from simple motor-driven commutator. Delay device shown in A is used to generate curved-channel signals

sequence, and the locus of points of simultaneous arrival is that line of which each point is X lineal units from the second station pulsed and $X + K$ lineal units from the first station pulsed, where K is a constant equal to ct, c being the speed of sound in water, and t the time difference between pulses in a given pair.

Case 3. They may be pulsed simultaneously, and the locus of points of fixed differential time (t') of arrival is that line in which each point is T seconds from the first station heard, and $T + t'$ seconds from the second station heard. Here T is analogous to X above, and $T + t'$ is analogous to $X + K$.

Case 4. They may be pulsed in sequence and the locus of points of fixed differential time (t') of arrival is that line in which each point is T seconds from one of the stations, and $T + t + t'$ seconds from the other station, where both t' and t are constants. Again T is analogous to X and $T + t + t'$ is analogous to $X + K$.

Referring now to Fig. 2, Stations 1B and 2B are shown with a straight line D drawn between them. The actual shape of course line B depends not only on X and $X + K$ as developed above, but also on the length of D, which is apparent from Fig. 2. If we assume that Station 2B is pulsed before Station 1B, then in accordance with Case 2 above, the locus of points of simultaneous arrival of the first arrival signals from both stations is that line which is everywhere X lineal units from Station 1B and $X + K$ lineal units from Station 2B. This locus can be determined as shown in Fig. 2, using one of the standard methods by which hyperbolas are constructed in elementary descriptive geometry. The distance D being fixed, the amount of curvature of the hyperbola drawn is governed by the value of the constant K, which is to say, by the fixed amount of time delay between pulsing of the two generators 1B and 2B, since c is the same for sound from both stations. It will be recognized that the constant K represents an identical elapsed time in the travel of both signals to the observer. It will likewise be appreciated that the foregoing discussion applies equally well to Cases 3 and 4 mentioned above, being understood that K includes also the fixed differential time of arrival.

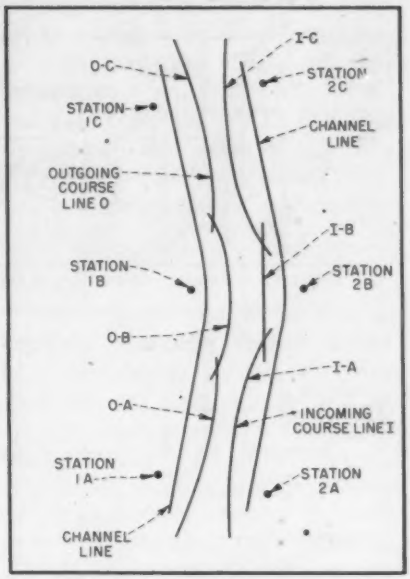

FIG. 5—Incoming and outgoing channels can be indicated by observing time differences

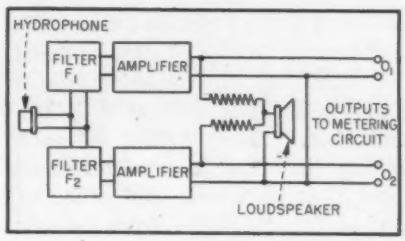

FIG. 6—Time difference indicator

When the bend in a channel is slight, it is not always necessary to curve the course line to fit, but, depending on the width of the channel, the conditions to either side of it, and the traffic problem, it may often be satisfactory merely to employ a series of straight course lines having different respective directions. Such an arrangement is that of Fig. 3, which is otherwise the same as that of Fig. 1.

Receiving Equipment

As stated, a vessel need be equipped with only the simplest kind of listening apparatus in order to take some advantage of the system. Such an apparatus might comprise a hydrophone connected to a suitable amplifier, which furnishes output signals to a loudspeaker. The hydrophone is omnidirectional in construction and installation. An even simpler arrangement, a stethoscope-like listening arrangement known as a sea tube can be employed. Or, in a more elaborate electronic equipment the two pulses can be separately amplified and compared, as in the arrangement shown in Fig. 6. The hydrophone then feeds into two filters in parallel, each of which passes only the frequency of one of the stations. One filter is set for f_1 (600 cps) and the other filter is set for f_2 (900 cps). Each filter feeds into an amplifier which provides two separate output signals at O_1 and O_2, respectively. The loudspeaker is provided with the output of both amplifiers simultaneously by a bridging or isolating circuit arrangement. The output signals have sufficiently high level for use in an automatic electronic time comparison circuit. Such a circuit is shown in Fig. 7.

Keying the Transmitters

The signal generating equipment is composed of conventional parts, as in Fig. 4A. A keying device or coder controls the output of two transducers, one for each station of a pair. The coder generally comprises a pair of switch contacts and a motor-driven commutator. The commutator has a group of switch segments each of which is successively closed. One segment, in this instance, is of a given length, and the other two are longer so that when the commutator is rotated in the direction indicated by the arrow, the code letter W is generated. The coder keys two drivers, one for each of the two transducers, respectively. The keying signal to one of the drivers is fed through a device that serves to delay the output from one transducer with respect to that from the other transducer. Thus, if these transducers are the sound producers for Stations 1B and 2B of Fig. 1 respectively, the system of Fig. 4A can be set up to emit, for each keying operation of the coder, a pulse from Station 2B and thereafter a pulse from Station 1B, the time between these pulses being controlled by the delay device. The delay device can be omitted where a straight path (Stations A or C) is desired, or placed in the line to the

other driver if the curvature of the path is to be reversed.

The possibility of confusion when the navigator is transferring his observations from one pair of stations to the next pair along his path has already been noted. The arrangements shown in Fig. 4 are provided to eliminate such confusion completely, and are particularly valuable in crowded harbors or in channels where the region to either side is dangerous. To enable a navigator to distinguish between sets of stations, the various pairs may be provided with characteristic codes. Thus, the A stations may be pulsed with a dash, while the B stations may be pulsed with two dots, and the C stations with a dot and a dash.

Confusion between adjacent pairs of stations can be minimized also with the system shown in Fig. 4B. There each of the pairs of stations is brought to a commutator switch driven by a motor. The switch functions in the usual manner to key the pairs of stations in succession, one pair at a time. Keying is maintained at a low repetition rate so that a navigator will not hear the signals of two pairs of stations together. This arrangement also permits reverberations to die out between the keying of adjacent stations. The arrangement of Fig. 4B also enables a navigator to pick out the signals of the next pair of stations that he is going to use before he begins actually to use them.

In Fig. 4C the coding arrangement of 4A is incorporated into the system of 4B by placing individual coders in the lines between the commutator and the pairs of stations, thereby keying the respective pairs of stations through their own individual coders.

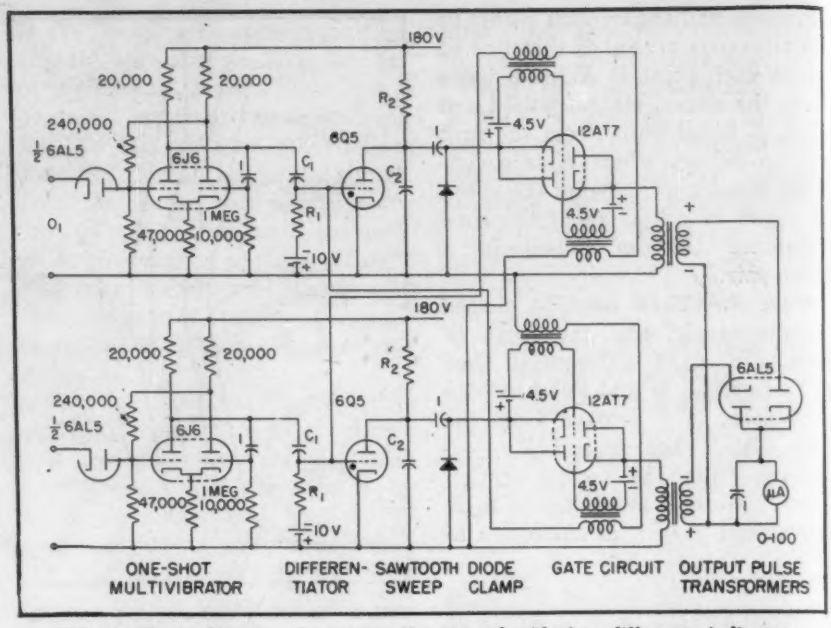

FIG. 7—Circuit diagram of metering circuit used with time difference indicator

Multichannel Navigation

Now, by arbitrarily choosing two sets of particular fixed time differences and orders of arrival for each pair of stations, two separate marked paths can be provided for incoming and outgoing traffic. Figure 5 illustrates how an incoming course line I and an outgoing course line O are provided in the same channel, so that two-way traffic can be handled. The incoming course line I is made up of section I-A for stations 1A and 2A, section I-B for Stations 1B and 2B, and section I-C for Stations 1C and 2C. Similarly, the outgoing course line is made up of sections O-C, O-B, and O-A. Each section of each course line has a predetermined fixed time difference and order of arrival for the pulses from its pair of stations.

Where the channel is straight or nearly so, the stations of a pair are pulsed simultaneously, as in Case 3. Such stations are the A stations and the C stations. A navigator negotiating the incoming course line I is then in a position to hear the No. 2 member of each of these pairs first, while on the outgoing course line O he will be in a position to hear the No. 1 member first. Where the channel curves to an appreciable degree, the two B stations are pulsed in sequence (as in Fig. 1). Then Case 4 applies, and the navigator on the incoming course line negotiates a path that is nearer to the No. 2 station than to the No. 1 station; even nearer than is the corresponding course section B in Fig. 1. As a result, the signal from Station 2B not only starts first, but also arrives first. Referring again to Fig. 2, it is recalled that circles X_1 and X_2 exist simultaneously, while Y_1 and Y_2 exist simultaneously, and the same is true of Z_1 and Z_2. However, if the navigator is to occupy a position such that the wavefront represented by circle X_2 passes him first, and then, a fixed time later the wavefront represented by circle Y_1 passes, which is the condition when he negotiates incoming course section I-B, then the line that determines section I-B is the locus of points L_1, L_2, L_3 and L_4, which has considerably less curvature than line B. This is to be expected, for the curvature that is imparted to line B by starting the pulse from 2B prior to 1B and receiving them simultaneously is changed in Fig. 5 by receiving the pulse from 2B prior to the pulse from 1B. For the same reasons, the outgoing course section O-B has a more pronounced curvature than line B in Fig. 1, for here the pulse from 2B is not only started earlier than the 1B pulse, but it is also received later. From the navigator's point of view, the effect is the same as on the straight stretches of the channel; on the incoming course the Station 2B pulse arrives first, and on the outgoing course the 1B pulse arrives first.

Thus the navigator may regard the course line in Fig. 1 as the center-line of a highway, and by keeping the pulses of one pitch coming in before the pulses of another pitch, he keeps to the right of the center line. From his charts, he can determine exactly what the time difference should be for each pair

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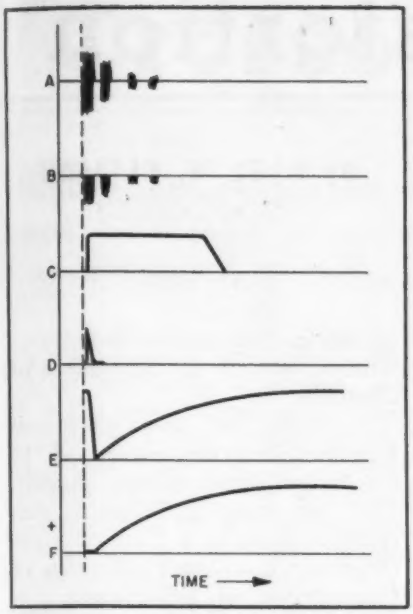

FIG. 8—Waveform oscillograms in time difference circuit

of stations to keep himself in the best path to the right of center. The time differences that he must observe for each line for each pair of stations will be furnished to the navigator in advance as part of his instructions for conduct while entering and leaving the harbor. He may employ the arrangement shown in Fig. 6 for determining that he is on a proper course line section. Such an arrangement is particularly valuable in that it tends to reject extraneous noise signals, such as propeller noises from other ships. With this apparatus, the ear alone can be depended upon to recognize and maintain a small time difference between two signals of a pair of stations, making possible safe navigation with very simple listening apparatus. For accurate measurement of the time difference, however, the navigator can employ the indicator shown in Fig. 7.

This time difference indicator employs two identical channels, one connected to output O_1 and the other to output O_2 of Fig. 6, in each of which there is generated a single voltage pulse trigger in response to the first arrival signal from the corresponding station of the pair under observation. Each pulse trigger initiates a sawtooth voltage wave in its own channel and controls a normally open gate stage in the other channel. The output of the sawtooth voltage stage of each channel is momentarily made available, through the gate circuit of that channel, to a meter into which both channels feed, and which indicates the amount and sense of the time difference. Since both signal channels are identical, only one need be described.

Channel Indicator Circuit

Each signal channel includes a one-shot multivibrator, a differentiating circuit, a sawtooth sweep generator, a gate circuit, and an output pulse transformer. The multivibrator is set up so that the first triode is normally conducting in the absence of signals. A diode is provided in the input circuit of the one-shot multivibrator and connected so that negative voltages only appear on the control grid of the normally conducting triode in response to signals from the station under observation. As shown in Fig. 8, at A, the signal from a station consists of a first arrival wave train of comparatively large amplitude, plus reverberations. The negative portion of this signal, shown at B, appears on the grid of the triode. This signal initiates the action of the one-shot multivibrator whose time constants are set up to be long enough to prevent reversal until all reverberations and other signals have disappeared. The differentiating circuit has a time constant C_1R_1 of the order of 1 millisecond, and produces a short positive pulse across R_1 marking the leading edge of the multivibrator reversal (C). This pulse is shown at D.

The sweep generator is an RC circuit (R_2C_2) triggered by a thyratron. The control grid of the thyratron is triggered by the differentiating circuit R_1C_1. Thus, a semisawtooth voltage wave is provided as shown at E. The sawtooth voltage wave is sampled by a gate circuit.

A diode clamp is connected across the output of the sweep generator on the isolated side of the channel. The sweep voltage that is available to the gate circuit is shown at F. This sweep voltage starts at the zero level because of the diode clamp.

The gate circuit is a conventional back-to-back triode gate. Each section is biased to cutoff, as shown, and is provided with a grid-input-control pulse transformer. The O_1 channel gate is connected to the differentiating circuit of the O_2 channel, and the O_2 channel gate is connected to the differentiating circuit of the O_1 channel. Thus the O_1 channel gate is controlled by the positive pulse from the O_2 channel, and the O_2 channel gate is controlled by the O_1 channel.

The secondary windings of the output pulse transformers of the O_1 and O_2 channels respectively are connected to a normally centered meter which is deflected to one side or the other depending on the magnitude and direction of the output signal. The two secondary windings are so phased that their output signals deflect the meter needle in opposite directions, and each is connected to the meter through a suitable rectifier.

If the two first arrival signals from a pair of stations are picked up in sequence, one is fed through O_1 to one channel, while the other is fed through O_2 to the other channel. The pulse trigger (Fig. 8D) which corresponds to the first signal opens the gate in the second channel, but since the second channel has not yet received any signal, there is no sweep voltage to be sampled through the opened gate. This same pulse, however, starts the sawtooth wave in its own signal channel. Thereafter, the trigger pulse from the second channel opens the gate in the first channel and a pulse having a peak voltage determined by the instantaneous level of the sawtooth voltage in the first channel is applied to the output circuit. Thus, the sampled output of only one of the sweeps is applied to the meter, namely, that which comes from the signal channel carrying the first signal received, and the voltage level at which it is applied is determined by the time difference between the two signals. If the two signals are received simultaneously, both trigger pulses occur simultaneously and the meter will not deflect. The loudspeaker will at all times furnish the information that the signals are being received, so that an operator need refer to the meter only at intervals to secure an accurate measurement of the time difference.

Low-Distortion

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TRANSFORMERS are recognizable as sources of distortion due to the nonlinearity of the inductance, which gives rise to an exciting current that contains components other than the fundamental. The same nonlinearity also produces intermodulation distortion.

The crossover network can be used to reduce transformer distortion by placing at least part of the low-pass filter between the power source and the low-frequency output transformer, instead of between the output transformer and the load.

Consider an output transformer operating between a high-impedance tube source and a 5,000-ohm load (referred to the primary side). Assume the primary inductance to be 26 henrys. At 30 cycles $\omega = 190$ and $\omega L = 5{,}000$. The shunt reactive load, equal to the resistive load, would produce a response which is 3 db down at 30 cycles. This is considered good response.

Next consider that the exciting current contains a considerable harmonic content. At ordinary power levels the third harmonic would typically be about one-third the amount of the fundamental current. This harmonic current, flowing in the generator impedance, produces a distortion voltage which is then fed to some other load, such as a high-frequency channel.

Evidently, a much higher primary inductance is required for reasonable distortion than would be required merely to give a flat response.

The circuit of Fig. 1A is an approximate equivalent of a tube source G_1 having a tube impedance R_P, feeding a transformer having a winding resistance R_T and primary inductance L. The distortion components are considered as being produced by generator G_2. This added generator produces harmonic voltages and intermodulation products.

The crossover network arrangement of Fig. 1B accomplishes two major purposes. First, the low-pass filter $L_1 - C_1$ attenuates high frequencies propagating in either direction. Voltages produced by G_2 are attenuated before reaching tube impedance R_P, so that relatively less distortion voltage is available at R_P for transmission to the high-pass channel.

Second, $L_1 - C_1$ attenuates high frequencies from G_1 propagating to the transformer, so that a narrow range of frequencies is received by T_1. The modulation products generated in T_1 (represented by G_2) are therefore of lower order than would be the case if the transformer were required to handle the entire spectrum. Furthermore, such modulation products from G_2 are again attenuated in their transmission back to the impedance of the tubes.

Obviously, both these effects reduce the distortion which can be fed to the high-frequency channel. The most annoying distortion generally appears as a form of high-frequency noise, and reduction of transmission of low-channel distortion to the high channel reduces this form of distortion.

This network system, by limiting the distortion produced by the nonlinear exciting current of the low-frequency output transformer and by limiting the transmission of such distortion back into the rest of the system, offers a double-dose cure for over-all distortion.

The network of Fig. 2 has already been described in some detail.[1] This circuit was originally developed primarily for purposes of economy. Since the original publication, some of the reasons for the superior performance have been studied, with the result that the advantage of lower distortion is now recognized as of greater importance than the reduced cost.

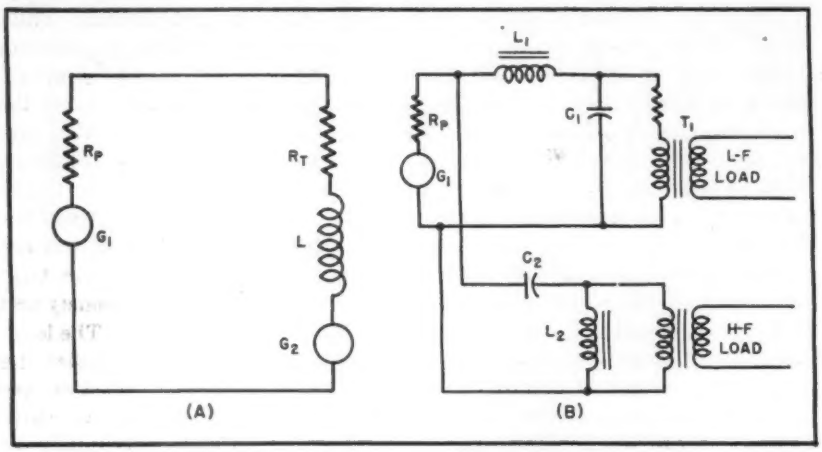

FIG. 1—Equivalent circuit of output tube, and recommended crossover network arrangement for reducing distortion due to inductance of output transformer

Numerical Example

For the conventional tube output circuit one may set up transformer requirements. Taking the exciting current as composed of a fundamental component $I_1 = E/\omega L$ and a third harmonic content $I_3 = (1/3)\ I_1$, consider a tube source with R_P of 2,000 ohms working into a load of 5,000 ohms, and consider a low-end cutoff of 31 cycles. Assume we want to limit third harmonic distortion to 0.5 percent or 0.005 per-unit of the fundamental.

The inductance can be determined from

$$L = R_P/3\omega_1 D \qquad (1)$$

where L is the primary inductance of the transformer, R_P is the plate

Crossover Network

If placed between the output stage and the low-frequency output transformer, an audio crossover network for woofer-tweeter loudspeakers reduces distortion due to nonlinearity of transformer inductance and makes special transformer designs unnecessary

impedance, ω_1 is the angular velocity of the lowest frequency, and D is the per-unit distortion. (Distortion D is the product of the harmonic component of exciting current times the tube impedance, divided by the fundamental voltage. The exciting current (fundamental) was $I_1 = E/\omega_1 L$. I_3 is taken as $I_1/3$, so $I_3 = E/3\omega_1 L$. $I_3 R_p = DE$ so $D = 1/3\omega_1 L$ or $L = 1/3\omega_1 D$.)

Putting in numerical values, $L = 2{,}000/3 \times 200 \times 0.005 = 667$ henrys. This is a difficult value to achieve, doubly so if the leakage inductance is to be held to a minimum dictated by a top limit of transmission of say 15,000 cycles.

If the transformer is required to transmit only the lower part of the total spectrum the leakage inductance limitation is removed and a transformer with realizable ratio of primary-to-leakage inductance can be designed. Therefore, placing the low-pass filter ahead of the transformer relaxes its design requirements relative to maximum primary-to-leakage inductance ratio.

Placing the filter ahead of the transformer also reduces the required primary inductance for a stipulated distortion. First, the filter attenuates in each direction, so that harmonics and other distortion products arising in the transformer are attenuated before getting back to the generator where they can be transmitted to the high channel. Second, the higher frequencies are attenuated in a forward direction so that the distortion products arising in the transformer are of low order.

Thus, conventional transformers with primary inductance values of the order of 100 to 200 henrys can be used, instead of special designs with values like 667 henrys. Further, since the transformer is required to transmit only up to the crossover frequency, say 500 cycles, the leakage inductance is not a severe design requirement and the transformer may be a relatively low-priced unit.

Appendix

An examination of Eq. 1 and its derivation indicates the desirability of keeping the plate impedance low. Triodes, with or without feedback, and the more efficient beam tubes with voltage feedback, both offer the desirable low impedance. Either can be designed for any desired characteristics. It should be noted, however, that reducing the driver stage impedance to zero would still leave the transformer winding resistance, so a loudspeaker would never look back into zero impedance.

In the numerical example, the figures chosen would apply either to a pair of 2A3 (6B4G) tubes in push-pull without feedback, or to a pair of 6L6 tubes with about 15 db of voltage feedback.

To reduce the plate impedance to zero or near zero values might appear to be highly desirable. However, the characteristics of the driven loudspeakers are such that some source impedance is desirable. Even in highly developed horn loudspeakers, the efficiency and impedance vary, and the source impedance tends to smooth out the resulting response. In the case of direct radiators with the 20 to 1 variations in impedance a constant-voltage source is not the best.

Thus, feedback to reduce output impedance would appear capable of being carried too far. Feedback for distortion reduction can be applied simultaneously as voltage feedback which tends to reduce the tube impedance (make it constant voltage) and current feedback which tends to increase the impedance (make the source constant current). A happy combination of the two might prove to be the best overall.

Here one is faced with the desirability of an optimum impedance for operation of the loudspeakers, and a minimum impedance from the standpoint of distortion in the transformers. The crossover arrangement discussed here offers the possibility of minimizing transformer distortion while maintaining the tube impedance at optimum levels from the standpoint of loudspeaker operation and distortion.

Either voltage or current feedback reduces distortion in the tube system (and both together reduce distortion to the same extent as would the same amount of total feedback of either type by itself). A combination of both affords any desired impedance, so it appears that the designer is free to design the amplifier for optimum loudspeaker performance, relying on the described crossover to hold the distortion from reasonably good transformers within tolerable levels.

In the numerical example, a low cutoff of 31 cycles was chosen. There are very few loudspeakers that will reproduce a 30-cycle fundamental. If one is dealing with direct radiators of moderate size cutting off around 70 to 90 cycles, the improvements afforded by the present crossover will be but slightly noticeable. But if one starts working with organ reproduction or generation where low-C performance is demanded, some very annoying distortions crop up. It is particularly for the users of reproducers capable of 30-cycle performance[2] that this article is written.

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Light-Flash Generator

Flash repetition rate may be continuously varied between 12 per minute and 150 per second. Flash duration is continuously variable from 400 microseconds to 2 seconds. Either of two light sources may be made to precede the other

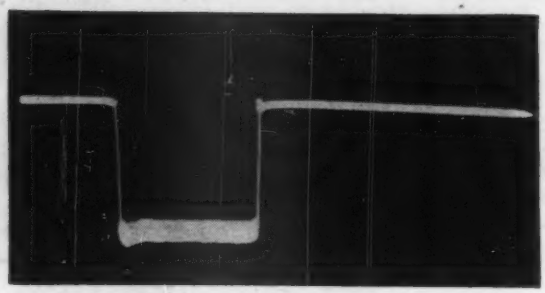

FIG. 1—Waveform of 400-microsecond light flash

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IN MANY FIELDS of visual research, a convenient method of generating controllable light flashes is desired. For example, studies of flicker can be greatly simplified if a system is available for the production of a repetitive light flash which can be varied in duty cycle without changing its rate of presentation.

The problem of producing such a flash by mechanical means is a difficult one if flexibility of adjustment is required. To overcome many of the problems associated with a system of this nature, an electronic flash system has been developed and is described in detail in this paper.

General Description

The equipment was designed to permit presentation of one or two light-flash sources. These light-flash sources may be presented at repetition rates continuously variable from one flash in five seconds to 150 flashes per second. The duration of each flash is continuously variable from a minimum value of 400 microseconds to a maximum of 90 percent of the period of presentation, or about 2 seconds. Either of the two flash sources may be delayed in time of presentation with respect to the other from a minimum value of 1 millisecond to a maximum of two seconds, the maximum available delay time being limited at all times to the difference between the period of repetition and the duration of the flash.

The light flashes are produced by exciting a facsimile recording light source of the glow-modulator type, such as the Sylvania R1131, with a voltage of rectangular waveform and of the desired duration. The tubes are of the hollow-cathode or crater type which produce a high ionization density when excited. They are designed in such a manner that this discharge is viewed in depth, thus giving a resultant flash of high intensity having spectral characteristics determined mainly by the type of gas employed and the ionizing current. In this application, the tubes are operated so that a considerable portion of the output energy lies in the visible spectrum.

Examination of the flash under dynamic conditions has indicated that there is no apparent shift in spectral characteristics during the flash period. Measurements were made by viewing the flash with a spectrally selective photometer[1] and examining the electrical output of the photometer on the screen of a cathode-ray tube. A typical waveform obtained by this method is shown in Fig. 1. The minimum pulse length of 400 microseconds was purposely chosen to illustrate the rapid build up and decay time of the flash.

Basic Operation

To demonstrate the basic operation of the individual timing circuits a functional block diagram of the equipment is given in Fig. 2. The voltage waveforms appearing at various points in this diagram are represented by Roman numerals. The numbers also appear frequently throughout the paper and refer to the correspondingly numbered waveforms given on the timing chart in Fig. 3.

The repetition-rate multivibrator shown in the functional block diagram provides an adjustable-frequency square wave (waveform I) from which a reference timing-trig-

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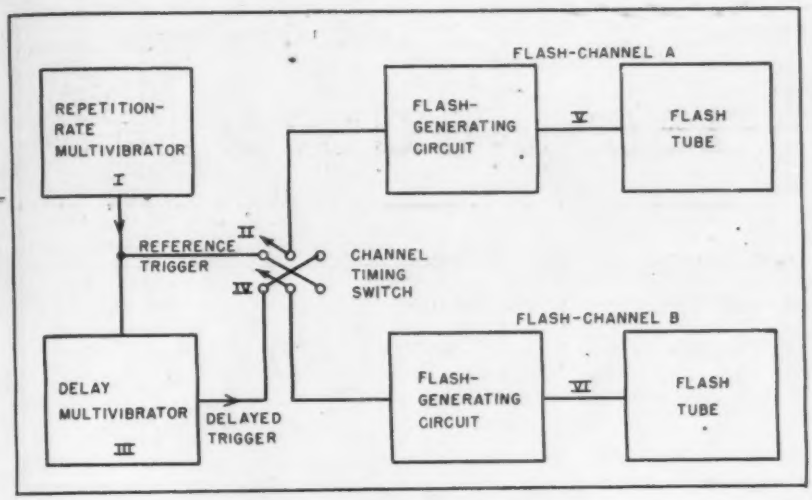

FIG. 2—Functional block diagram of light-flash generator

ger pulse (waveform II) is obtained for the system. This voltage is connected to the upper left terminal of the reversing switch labeled Channel Timing Switch and also is applied to the delay multivibrator as shown. In the latter circuit the reference trigger is delayed to provide a second timing pulse waveform IV similar in every respect to the timing trigger pulse but occurring at a subsequent time, t_d. The delayed trigger is connected to the lower left terminal of the channel timing switch and the output terminals of the switch are connected to the flash-generating circuits in the manner shown in the diagram.

Each of the flash-generator circuits consists of a single-cycle square-wave generator which is cycled by the timing trigger appearing on its input line. The output voltage of each of these circuits is developed across the flash tube in sufficient amplitude to permit the desired light intensity level to be realized. Since the flashes in each channel are initiated by the trigger pulses connected to their respective inputs, it can be seen that when the channel timing switch is in the left-hand position, the flash in channel A (waveform V) is cycled by the reference trigger (waveform II) and thus occurs at t_o. The flash in channel B is initiated by the delayed trigger and therefore occurs at t_d. When the switch is in the right-hand position the flashes are reversed in order of presentation (channel A has waveform VI), thereby providing an extremely useful device for temporal discrimination studies.

Reference And Triggers

The circuits of the reference and delayed-trigger sources are shown schematically in Fig. 4.

The period of the reference trigger is established by a cathode-coupled free-running multivibrator, V_1, whose period is determined by the R-C time-constant of its grid circuit. Coarse adjustments of repetition rate can be made in five steps by means of the capacitor selector switch S_1, and fine adjustments by means of the linear potentiometer R_2. The value of R_1 was so chosen as to limit the ratio of maximum to minimum period on any range setting to a value of six. This value represents the approximate limit of the ratio for continuously adjustable periods without introducing amplitude distortion of the multivibrator output voltage.

The output of V_{1B} (waveform I) is differentiated and negatively clipped by the combined action of C_6, R_6, R_7, and the series-diode clipper V_{2A}. Additional clipping action is provided by the inverted diode V_{2B}, so that the absence of any negative voltage at the grid of V_{3A} is assured. The voltage appearing at the cathode of V_{2B} is therefore a positive trigger (waveform II) which serves as a reference timing voltage for the system. The synchronizing trigger voltage is applied to the single-cycle delay multivibrator, V_3. The components of this circuit were selected so that V_{3B} is normally conducting and V_{3A} normally cut off. When the synchronizing trigger arrives at the grid of V_{3A} these conditions are abruptly reversed by the combined action of the feedback paths supplied by R_9 and the selected capacitor in the bank controlled by S_2. Tube V_{3A} is therefore conducting and V_{3B} cut off, a condition which is maintained until the grid potential of V_{3B} rises above the cutoff level. When this occurs, the conditions are again abruptly reversed, thus returning the circuit to its original state.

During the operating cycle, the current through the common cathode resistor R_9 is less than the normal quiescent current, since the tubes V_{3A} and V_{3B} are operated with different circuit components and under different bias conditions. The voltage appearing at the cathode of V_3 (waveform III) is therefore a negative square wave with leading edge coincident with the reference trigger (t_o) and trailing edge occurring at t_d, the time $t_d - t_o$ being established by the multivibrator cycle duration. In order that this delay time be realized in useful form, the square wave is differentiated and negatively clipped by C_{12}, R_{12}, R_{14}, and V_4, thereby creating a second positive trigger (waveform IV) delayed with respect to the reference trigger. Variations in the multivibrator cycle duration thereby produce corresponding variations in the time spacing of the two synchronizing triggers. Since this time is determined by the exponential decay of the grid potential

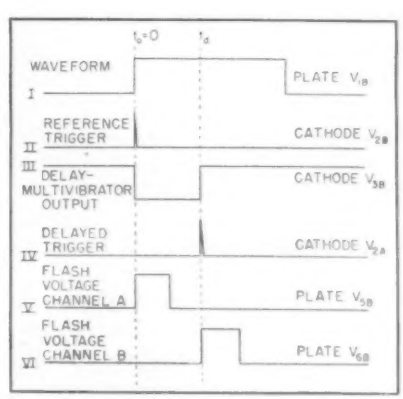

FIG. 3—Waveforms at various circuit points

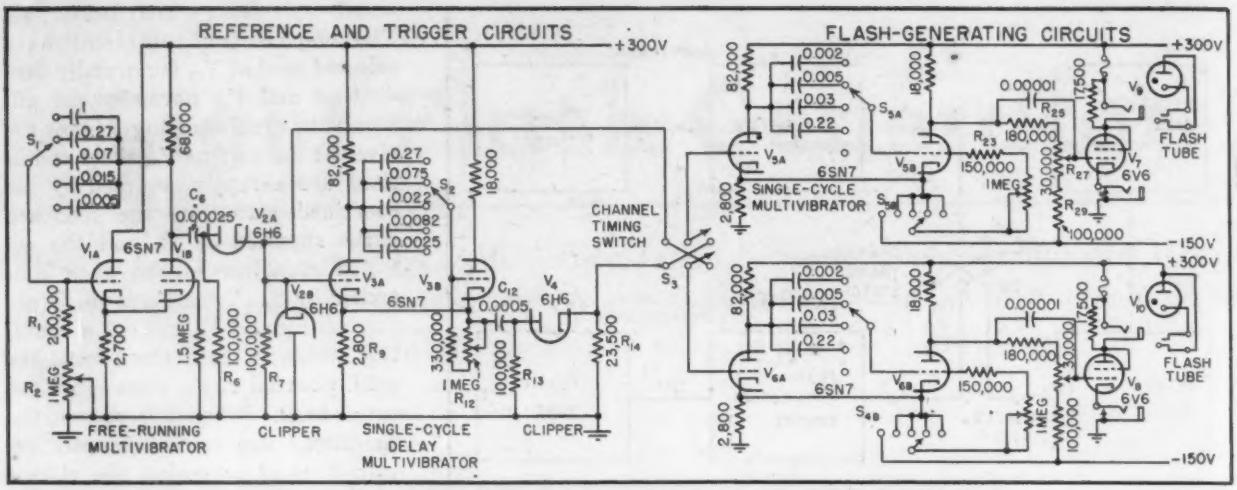

FIG. 4—Schematic of complete light-flash generator, less power supply

of V_{2B}, adjustments of the R-C time constant in this circuit produce direct variations of delay time. These adjustments can be made in five overlapping ranges by means of the capacitor selector switch S_2 and the linear potentiometer R_{12}, the combination providing continuous control of delay time in the available range.

Flash Circuits

The two trigger sources are connected to the two flash-generating circuits, included in Fig. 4, through the double-pole reversing switch S_3. Since both channels operate identically in every respect, the circuit description to follow will be confined to channel I, the channel shown in the upper-right portion of the diagram. The twin triode V_5, and its associated circuit elements constitute another single-cycle multivibrator whose operation is identical to that of the previously described delay multivibrator V_3. The output of this circuit, however, is obtained from the plate of the normally-conducting tube V_{5B}. Cycling of the circuit by the application of a positive trigger of sufficient amplitude will therefore initiate a positive-going rectangular wave at the plate of this tube (waveform V), the duration of the cycle being dependent upon the R-C time-constant in the grid circuit of V_{5B}.

The output voltage of V_{5B} is applied to one terminal of a voltage-divider network composed of R_{25}, R_{27}, and R_{29}, the opposite end being returned to the negative 150-volt supply. The variable tap on R_{27} is connected to the control grid of V_7, a triode-connected beam-power tube whose plate load impedance consists of the glow-modulator flash tube, V_9. Continuous excitation of this tube is prevented by adjusting R_{27} in such a manner that the grid bias on V_7 is well beyond that required for plate current cutoff during the quiescent period of V_5. When the latter is cycled, the positive gate voltage appearing at the control grid of V_7 drives this tube into the region of conduction, thereby exciting the flash tube.

Coarse adjustment of flash duration can be made by means of S_5 and fine adjustments by R_{23}, the combination permitting continuous control of flash durations ranging from a minimum of 400 microseconds to a maximum of approximately 2 seconds. When S_5 is in switch-position 5, the gridleak resistor of V_{5B} is returned to the 150-volt negative supply, thus placing the flash-duration multivibrator in a continuous-cycle condition permitting adjustment of the flash-tube intensity to the desired level. The intensity level obtained by this method will be the value to which the flash tube will be excited under dynamic conditions, since the intensity is a function of tube current only.

Calibration

The timing calibrations were obtained through the use of an audio oscillator and a cathode-ray oscilloscope of the type permitting beam-intensity modulation. The rectangular waveform to be calibrated is presented on the screen of the oscilloscope as a vertical deflection and the calibrating signal from the audio oscillator is superimposed upon this pattern as an intensity variation of the trace. To prevent drift of the intensity modulation of the trace across the pattern, the repetition frequency of the square wave must be a submultiple of the calibrating sine wave. This condition can be obtained by connecting the calibrating sine wave to the control grid of V_{1B}, thereby synchronizing the repetition-rate multivibrator with the timing signal.

By counting the number of spots present on the deflected portion of the trace, and multiplying this number by the period of the calibrating signal, the delay or duration time can be readily evaluated. The calibration of pulse lengths longer than 70 or 80 milliseconds by the above method becomes virtually impossible since the repetition rate of an 80-millisecond pulse must be less than $1/80 \times 10^{-3}$ or 12.5 pulses per second, at which frequency flicker effects are objectionable. For these and greater pulse durations a high-speed synchronous clock circuit[3] has been successfully used for calibration.

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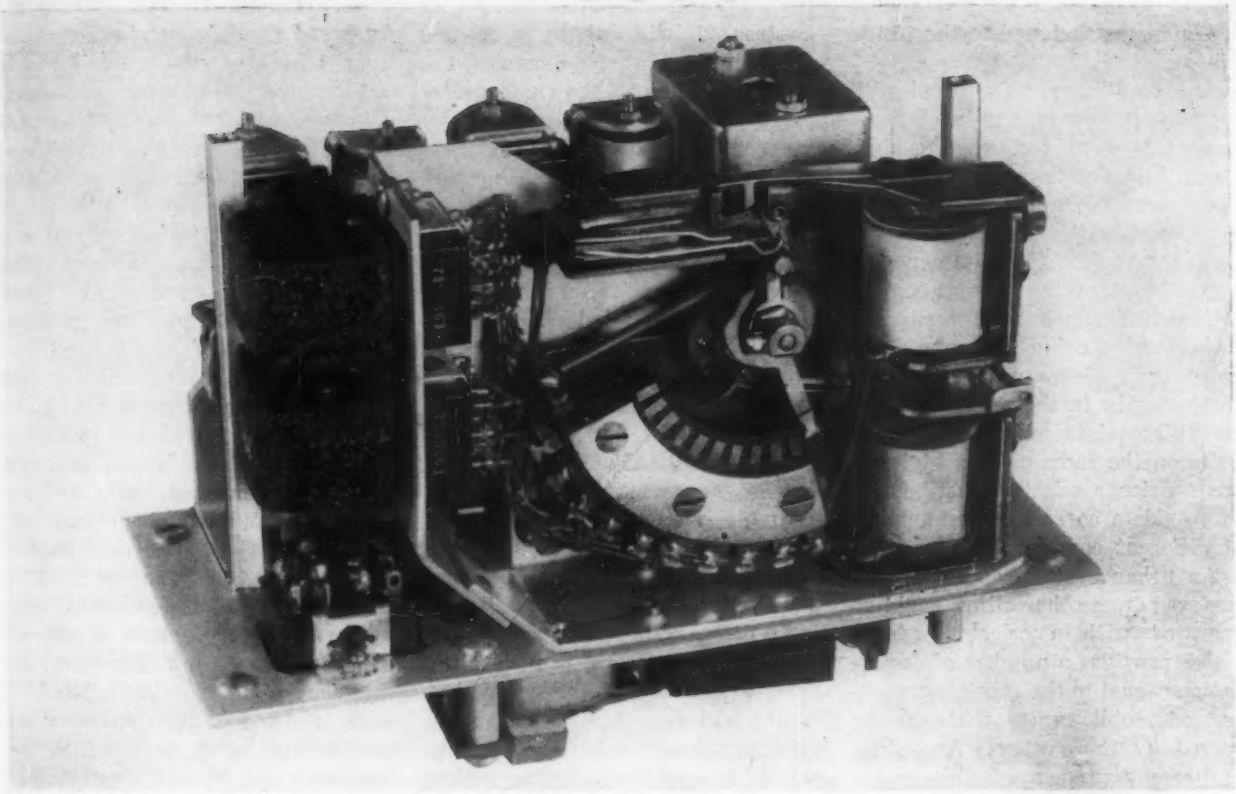

Stepping switch in center is controlled by incoming pulses and prewired connections of plugs at left. Audio peaking amplifier is on other side of partition. The whole unit can be plugged into a mobile receiver

Mobile Selective Calling

Mobile radiotelephone service for connection to wire telephone networks generally requires individual signal for each subscriber. A new low-cost decoder for dial-impulse selective calling can be used in areas now served by two-tone systems. A 2,600-cycle tone generator is added at the central office

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MOBILE RADIOTELEPHONE systems used by police and similar services generally employ a loudspeaker in the mobile unit to monitor all transmissions. Thus the operator of the vehicle must listen to all the traffic in the system and be on the alert to answer whenever his name, number, or code is called.

While such an operation is satisfactory to some groups there are other miscellaneous users, among the general public, for whom the constant monitoring of the channel is unacceptable. They prefer a bell or other signal only when a call is specifically meant for their mobile unit and, in addition, often want a permanent signal such as a light, to appear when such a call has been received while they are absent from the vehicle. In such cases, a selective calling or signaling system is needed.

One type of service offered by the telephone companies provides connection to the wire network and enables the mobile user to communicate with anyone that he could ordinarily reach from a wire telephone. Selector systems for this general service, using the dual-tone principle, have already been developed and are in use. The new selective calling system described here was specifically designed to be low in cost yet usable in a general service system. It is, moreover, equally useful in other types of service requiring selective calling.

System Requirements

Two types of general service are presently being provided. One is the highway service, which is designed to cover arterial highways and surrounding territory; the other is the urban service for vehicles chiefly engaged in local operations. For the former service, which generally requires somewhat larger ranges, frequency assignments have been made in the 30 to

40-mc range, while the urban service has been assigned to the 152 to 162-mc band.

In the highway frequencies, it was found necessary to introduce a zoning plan of frequency assignments in order to avoid long-range interference. On the basis of the number of systems expected in each zone and the mobile units expected in each system, the present computations indicate that the number of mobile units, using the same channel or pair of frequencies in each zone, may be in the order of 1,500. To differentiate among all mobile units on the same pair of highway frequencies, a selector must be able to provide a corresponding number of different combinations.

An urban system, operating far removed from other cities, could be operated with a selector system which provides a number of combinations equal to the maximum number of mobile units that can be served by the system. According to present experience, this would require somewhere between 50 and 150 combinations, depending on the traffic conditions in the particular system. Wherever cities are located close together, so that cars frequently travel from the coverage of one mobile system into that of another, a much larger number of combinations is again necessary. Such conditions exist, for example, in the northeastern Atlantic coast region.

To give the subscriber satisfactory service, at least three conditions must be met. A comprehensive regional plan must be worked out by all the telephone companies involved so that the necessary coverage is obtained without causing excessive overlaps. Arrangements must be worked out by the telephone companies so that a customer of one telephone company will receive service no matter whether he travels in the coverage of a system operated by the company to which he is a subscriber or that of another company. Finally, sufficient uniformity in equipment must exist so that a customer can have uninterrupted access to the service as he travels through the service area of different mobile-radio systems. The first two requirements have been met by the cooperative efforts of the different telephone companies confronted with these problems. Regarding the equipment, the standardization of the radio equipment is such that units made by different manufacturers can, in general, be used interchangeably provided that they are all adjusted to operate on the same channel.

In a local or urban system, far enough removed from other cities to minimize the chance of visits by outside units, any kind of selector system can be used provided it fits in with the general routine of traffic handling and does not require any other special treatment. For highway systems where the through customers already have dual-tone selectors and for urban systems adjacent to others using such selectors, it is still possible to use a different signaling system for the local customers provided the system meets the above requirements and that equipment at the central office can be arranged to signal to customers having either type of selector. Furthermore the additional provisions required at the central office should not result in any major cost differentials.

Fundamentals of Operation

The new selector system uses a single signaling tone in which the dial pulses that actuate the stepping mechanism of a multicontact switch are transmitted as interruptions of the tone. This tone is applied prior to the time that the operator starts dialing and is kept on for a short period after the dialing is completed. The selector returns to the idle or starting position whenever the dial tone is interrupted for any period materially in excess of the dial pulse duration. Thus the selector is self-resetting and does not require any special clearing pulses to reset it to zero. Such clearing signals are needed in systems where noise might activate the selector and leave it set in some intermediate position.

The fundamental circuit of the receiver unit is shown in Fig. 1. In the idle positions, all relays except the release control relay, *RC*, and the release magnet, *RM*, are deenergized, and the off-normal contact, *ONC*, is in the position shown. The pulse relay, *P*, is operated by the rectified audio-frequency voltages appearing across a circuit tuned to the dialing frequency. If a steady dial tone is applied, *P* energizes and in turn operates the slow-release relay, *SR*, which deenergizes the release magnet, *RM*, prepares the circuit for the stepping magnet, *SM*, and thus readies the stepping switch for operation. Subsequent interruption of the dial tone will operate the stepping magnet and cause the switch to step under control of the dial pulses.

As soon as the switch arm has left the first contact, the off-normal contact, *ONC*, is operated. This removes one ground from the *RC* relay which, being of the slow-release type, is now held operated by the pulsations of the *P* relay contact. The *SR* relay is likewise held

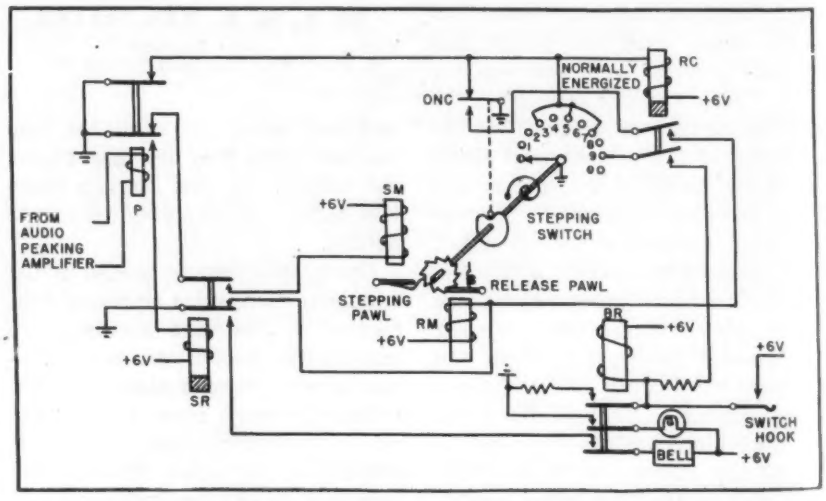
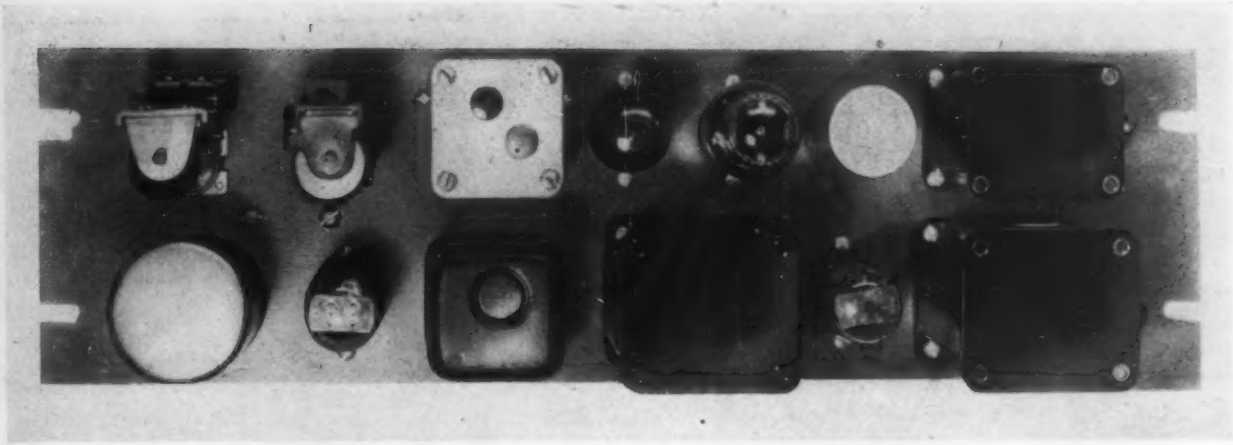


FIG. 1—Simplified schematic diagram of the decoder relay and stepping circuits



Tone generator and supervisory relays installed at central office

operated during these pulsations. At the end of a pulse series, the *RC* relay will release and, by operating the release magnet, return the selector to zero unless this pulse series left the switch on one of the specially selected contacts which are connected to the *RC* relay. If it comes to rest on one of these special contacts, the arm of the switch will provide ground for the *RC* relay which then remains energized. The release magnet is not energized; thus the switch will remain in this position and be ready to receive another series of pulses. The selection of these special switch contacts therefore determines the series of digits which must be dialed if the switch is to advance without setbacks.

The energizing circuit for the bell-ringing relay, *BR*, is connected to one of the latter contacts, for instance contacts 7, 8, or 9, on the switch; and the switch contacts beyond this point are left unconnected. If at the end of the last pulse series the switch comes to rest on one of these contacts, *RC* will release, as they are not connected, and thus cannot complete the circuit for *RC*. If the switch comes to rest on the contact to which *BR* is connected, *RC* will, when it releases, energize *BR*, which in turn will close a holding circuit through its own contacts. A very short time after this, *RM* pulls up and returns the switch to zero. Another contact on *BR* closes the circuit to the bell through a contact on *SR*. Thus the bell will ring until the *SR* relay is released by the interruption of the dial tone, which occurs shortly after the completion of the dialing operation. Another contact on the *BR* relay energizes a signal lamp, which remains lighted until the subscriber removes his handset. This operates the hook-switch, and releases *BR* by shorting its winding.

In the actual selector, the *BR* relay is replaced by a decade-switching relay *DS* which is energized in the same way as the *BR* relay and which holds itself over a contact on the *SR* relay. This relay transfers the holding circuits which were connected between the *RC* relay and the special switch contacts to a second set of contacts on the switch. In the meantime, the switch has returned to zero and has energized *RC*. It is thus ready for a new series of impulses; and, if the proper code is again dialed, it will then operate the *BR* relay which is connected in the second set of contacts in the same manner as described before. It is this utilization of two sets or banks of contacts on the stepping switch which provides the much larger number of combinations.

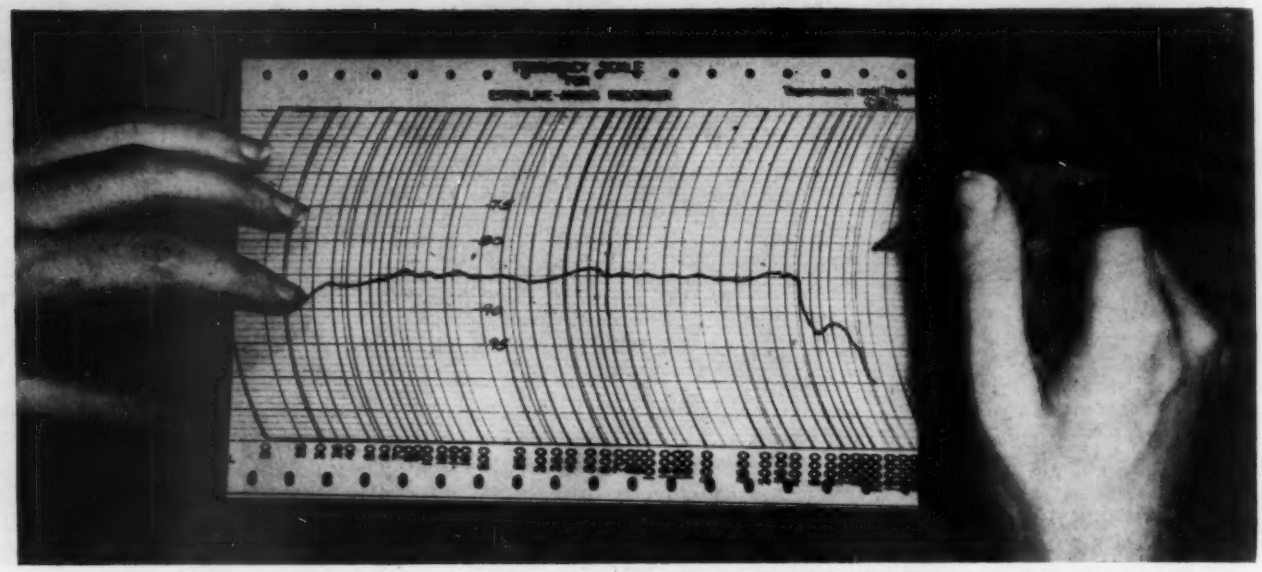
In addition to providing a large number of different possible combinations (about 1,500), the new selector also permits group calling. If both the decade-switching relay and the *BR* relays are connected to contact 9, then the dialing of 99 will call all cars. If in some cars the *DS* relay is connected to contact 9 and in others to 8, and if the same holds for the *BR* relay, then the subscribers may be divided into four groups having group calling codes of 99, 98, 89, and 88 respectively. Thus, for instance, the police department, the fire department, doctors, and the general public could be given group calls. If contact 7 is also similarly used, the number of possible group calls increases to seven.

Coding combinations are easily arranged by the insertion of two properly wired multicontact plugs into the mobile unit, one for each bank of contacts. This feature facilitates maintenance whenever all or part of the mobile equipment is removed from the vehicle. The code plugs are simply reinserted in a spare unit to give it the correct dial-response characteristics for the subscriber.

The decoder was built by Hammarlund Manufacturing Co., and was designed to be physically replaceable for the Fleet Control unit (described by J. K. Kulansky in ELECTRONICS, June 1946) for which provision has been made in several commercial models of mobile radio receiver chassis.

System Tie-In

Besides making provision for simple modification of existing Western Electric control units, without disturbing the original function, equipment has also been designed for central office use. A tone generator for 2,600 cycles and necessary relays for keying it in and out of service permit central-office signaling with either the new system or the existing two-tone system. A coded number assigned to the subscriber informs the operator which system she must use to complete the call.



Transparent frequency scale is held over response curve produced on chart paper of recorder

Microphone Calibrator

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THE FIELD CALIBRATION of a microphone requires that the microphone be placed in a plane sound field of known intensity. This type of calibration differs from a pressure calibration in that the effect of diffraction around the microphone is charged up as part of the response of the microphone. It is therefore the most useful type of calibration for microphones used in broadcasting.

Inexpensive Dead Room

Obtaining the required sound field indoors is a matter of some difficulty because reflections build up standing waves to give a nonuniform sound field. The usual method of obtaining the sound field by the use of free-field or anechoic chambers was felt to be too expensive for the present project, so two less expensive devices are used to obtain the required field, one operating from 30 to 1,000 cycles and the other unit operating from 1,000 to 15,000 cycles.

The two measuring techniques involved, outlined below, were developed for use on all microphones used in CBC studios across Canada. In both, the microphone being tested is compared against a standard microphone by a two-channel logarithmic voltmeter that automatically plots the response in decibels against frequency. The system can also be used for recording loudspeaker response and polar diagrams.

Low-Frequency Chamber

The frequency response from 30 to 1,000 cycles is measured by placing the microphone three feet from the end of a wooden tube 30 feet long and 11 by 11 inches in cross section. A drawing of the tube is shown in Fig. 1. At the end of the

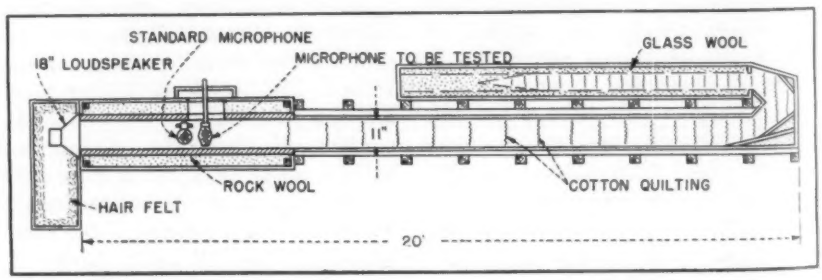
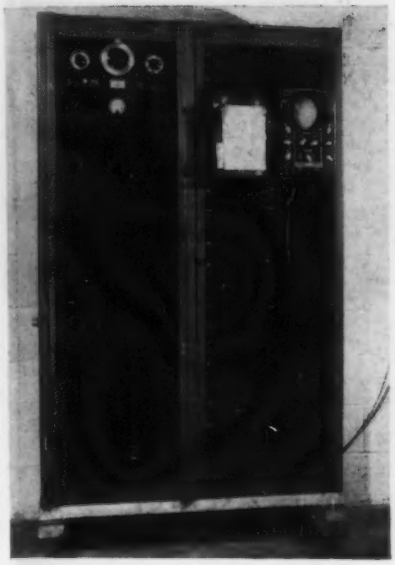


FIG. 1—Cross-section of 11-inch-square hollow wood tube used to absorb sound energy below 1,000 cycles from loudspeaker and thereby prevent reflection back to microphone being tested



Microphone calibration rack, designed to plug into a-c wall outlet

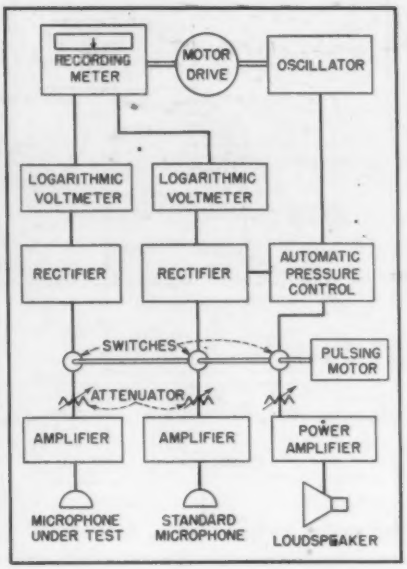


FIG. 2—Block diagram of microphone calibration rack used in CBC laboratories

Simple, rapid and reasonably accurate method of measuring sensitivity, frequency response and polar response without a costly free-field anechoic chamber. Below 1,000 cycles a long wood tube absorbs unwanted sound. Higher frequencies are pulsed and recording is done before reflected sound returns to microphone

tube near the microphone is a loudspeaker. That part of the tube on the far side of the microphone contains curtains of cotton quilting hung across the tube in increasing amounts to form an acoustic resistance to absorb the energy of the sound passing from the loudspeaker. The treatment is adjusted until the acoustic impedance looking into the tube is approximately that of open air, or 40 acoustic ohms per square centimeter.

With the source of sound located symmetrically on the axis of such a tube no standing waves exist across the tube for frequencies below 1,000 cycles, and the acoustic treatment effectively absorbs reflections from the end of the tube; the result is a plane wave flowing past the microphone. The tube can be used only below 1,000 cycles, because above this frequency standing waves exist across the tube.

Mounted beside the microphone being tested is a small standard microphone, having flat response over the 30 to 1,000-cycle range, and of known sensitivity. The outputs of the two microphones are fed to the measuring rack and as the frequency of the loudspeaker signal is slowly changed the response curve is automatically plotted.

High-Frequency Pulse System

Over the range above 1,000 cycles a pulsing system is used to obtain effective free-field conditions. The microphone to be tested and a small loudspeaker are set up about three feet apart in a studio or small room. Midway between the microphone and loudspeaker is placed a small standard microphone.

A short pulse of sound at the desired frequency is transmitted from the loudspeaker, and the resulting output from the microphone is measured before enough time has elapsed for reflected sound from the nearest wall to arrive back at the microphone. The pulse is repeated at intervals long enough to allow reflections to die out between pulses. During the pulsing the frequency of the oscillator driving the loudspeaker is slowly changed and the response curve is automatically plotted by a logarithmic recording voltmeter. By rotating the microphone undergoing test a polar diagram of the response at any frequency can be plotted.

Pulse Length

The length of the pulse that is used is 10 milliseconds and the pulse is repeated 10 times every second. With a pulse of 10 milliseconds length and a sound velocity of 1,100 feet per second the sound path before the first reflection can reach the microphone is 11 feet. This means that the microphone can be half this distance or within $5\frac{1}{2}$ feet of the nearest wall, hence a comparatively small room is suitable for the measurement.

At 1,000 cycles a pulse of 10 milliseconds consists of only 10 cycles, of which the first and last few cycles are obscured by transients, so that 1,000 cycles is about the low-frequency limit of this pulsing system. In a larger room a longer pulse could be used, and consequently a lower frequency could be reached. On the microphone channels the beginning and end of the pulses are clipped to remove transients from the pulses before comparing the two signals.

No special treatment is required on the walls of the room used for this part of the test, for the repetition rate of 10 per second allows sufficient time between pulses for reflected sound to drop to a negligible value before the next pulse is transmitted.

The sound source used for the high-frequency test is a small dynamic loudspeaker that was found to have adequate output up to 15 kc. As will be noted later, the response of the source is not critical in this method.

Standard Microphone

The standard microphone is a small type M101 crystal unit $\frac{5}{8}$ by 15/16 inch in size, manufactured by Massa Laboratories.[1] The pre-

amplifier housing supports the standard microphone in the position for minimum diffraction effect, with the end of the crystal unit parallel to the sound axis. In this position the diffraction effect is negligible below 10 kc, and the response can be considered flat. A reciprocity calibration on this unit gave a value of sensitivity in good agreement with the value stated by the manufacturer.

The preamplifier housing contains a 9002 tube connected as a cathode follower, acting as an impedance changer between the high impedance of the crystal and the low-impedance output. Terminals are provided on the preamplifier for injecting a signal in series with the crystal for making overall electrical calibration of the associated equipment.

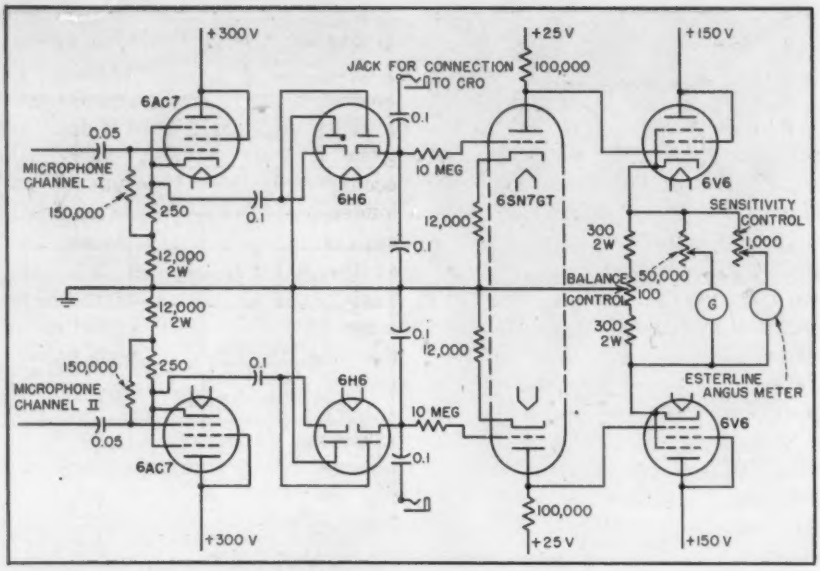


FIG. 3—Circuit of voltmeter providing logarithmic amplification over range of 46 db as required for plotting response curves in db

Tests have shown that at the testing distances used, 15 inches to the standard microphone and 30 inches to the other microphone, neither microphone has appreciable influence on the sound intensity at the other, and for the period of the pulse each microphone is in a progressive sound wave, the pressure at the nearer microphone being twice that at the other. In the low-frequency tube an inexpensive crystal microphone is used as the standard, and is checked at intervals against the Massa standard.

The absolute accuracy of the measurements depends upon the standard microphone, but the type of crystal microphone used appears to be stable, and a reciprocity calibration can be made upon it at any time if required.

Rack Equipment

Both parts of the calibration method require the comparison of the outputs of the two microphones. This comparison is carried out in the rack of equipment shown in the block diagram in Fig. 2.

The rack contains amplifiers for the two microphone channels, a logarithmic voltmeter which compares the outputs of the two microphones, a recording meter, an audio oscillator with a motor drive on the frequency dial, a power amplifier to drive a loudspeaker, an automatic pressure control, pulsing switches and a cathode-ray oscilloscope for waveform examination.

The two microphone channels are similar, each consisting of an amplifier, attenuator, rectifier and logarithmic stage. The attenuator controls are marked directly in decibels on the front panel. Each amplifier is followed by a cathode follower, using a 6AC7 as shown in Fig. 3 to provide a low-impedance source and so avoid peak clipping by the rectifier action. The 6H6 rectifiers are connected as voltage doublers. The maximum undistorted signal available from the cathode follower is about 100 volts, hence the peak d-c output from the rectifier is about 200 volts, or 46 db above the minimum usable output of 1 volt. Below 1 volt the initial current from the diodes becomes important, introducing nonlinearity.

Since only the amplitudes of the pulses are compared, the rectifier circuit has a short charge time constant, in order that the amplitude of the signal can rise to full value during the first millisecond of pulse. The discharge time constant is long, however, in order that the rectified level does not fall appreciably during the tenth second between pulses.

Logarithmic Action

Logarithmic action is obtained by applying the positive voltage from the rectifier through a 10-megohm resistor to the grid of a 6SN7GT triode section operating with 25 volts plate supply. Because the emission velocities of the electrons given off by a hot cathode follow a Maxwellian distribution, the grid current which flows bears a logarithmic relation to the applied voltage. This logarithmic change in grid current produces a corresponding change in grid-to-cathode voltage, which is amplified and appears as a change in plate potential. The circuit as developed by Walter Ives[2] is accurately logarithmic over about 46 db, the limitations lying not in the log tube but in the rectifier and amplifier ahead of the log tube.

The direct-current output of the two logarithmic stages is further amplified by direct-coupled 6V6 tubes connected as cathode followers and fed to the recording milliammeter, which is a standard 5-ma Esterline-Angus meter. A potentiometer at the midpoint of the cathode resistors of the 6V6 tubes enables the two channels to be balanced so that equal signals on the two channels give center-scale deflection of the meter. This meter responds to the difference between the output of the two channels, and so is equivalent to the difference of the logarithms of the two microphone signals, and hence to the ratio of the two microphone responses. Since the response of the standard microphone is known to be flat, the result is the response curve of the unknown microphone plotted in db

against frequency on the recording meter chart.

Recording Method

A sensitivity control in series with the meter can be set so that one division of the chart paper represents one db. The absolute sensitivity represented by the center line on the chart is found by subtracting the difference in gain of the two microphone channels, easily read off the two panel attenuators, from the sensitivity of the standard microphone. The two-channel construction tends to balance out effects of line voltage variation. In addition, electronic regulation is used on the plate supply for the logarithmic stage and direct-coupled amplifier. The stability of the gear is sufficient so that measurements remain accurate to within one db over long periods.

A small motor synchronized with the paper drive on the recording meter slowly changes the frequency of the oscillator driving the loudspeaker. The speed at which the oscillator frequency can be varied is dependent on the time constant of the rectifiers, which is relatively long. Even with this restriction, however, it only takes three minutes to traverse the frequency range from 30 to 15,000 cycles.

The curved coordinates produced by the meter are not as convenient to use as rectangular coordinates, but when a transparent scale marked in frequency is laid over the chart the sensitivity at any frequency can readily be read off.

For the low-frequency test in the tube no pulsing is used. The oscillator frequency is simply varied slowly as the response is plotted. For the high-frequency test the loudspeaker signal must be pulsed. This is done by a motor-driven commutator-type switch which shorts the oscillator signal except for the period of the pulse. Other commutators mounted on the same shaft short the microphone channels for a slightly longer period, clipping the transients from the beginning and end of the loudspeaker pulse. These commutators have to be phased on the shaft to allow for the time interval taken by the sound in travelling from the loudspeaker to each microphone.

It is difficult to find a loudspeaker or any sound source that has an output independent of frequency, but since this method compares the outputs of two microphones it does not greatly matter what variations occur in the sound output of the loudspeaker. However, to maintain approximately constant sound level at the microphone and to insure that the 46-db range of the voltmeter is not exceeded, a portion of the output of the standard flat-response microphone is fed to the automatic pressure control, a variable-gain amplifier in the loudspeaker circuit. Here it controls the signal fed to the loudspeaker, increasing the output when the loudspeaker response drops, and decreasing the output when it tends to increase.

The cathode-ray oscilloscope mounted in the rack is useful for visual checks on wave form. It quickly shows up, for example, the characteristic distortion produced in a velocity microphone when the ribbon strikes a pole piece during part of a cycle. The picture of the pulse received by a microphone will show up excessive distortion if present, but unfortunately the pulsing system is not easily adapted for distortion checks, although very satisfactory for response measurements. When checking loudspeakers the shape of the pulse is very useful for giving a qualitative measure of the transient response.

Polar Response Curves

For normal tests the microphone is terminated at the input of the rack in a resistive load of 500 ohms, corresponding to the input impedance of standard speech equipment. The response curve then includes the loading effect of the termination on the internal impedance of the microphone, an effect which in most microphones reduces the sensitivity at the higher frequencies. If desired, other terminations may be selected by a panel switch. The stand carrying the microphone under test can be rotated by a small motor for the automatic plotting of polar response curves.

Besides measuring the response of microphones, the equipment using the pulsing system can be used to measure the response and polar distribution of loudspeakers above 1,000 cycles. For this test the standard microphone is placed in front of the loudspeaker to be tested, and a portion of the voltage applied to the voice coil is fed to one of the microphone channels in the rack. The curve plotted is the acoustic output of the loudspeaker for constant voltage on the voice coil, corresponding to the response that would be obtained if the loudspeaker were fed from a source having zero internal impedance. The response curve for other source impedances can be calculated from impedance measurements, or quickly plotted by placing the desired impedance in series with the voice coil after the point at which the comparison voltage is picked off.

Conclusion

The equipment described has been in routine use for almost a year. Since the calibration procedure is rapid and almost automatic the effects of adjustments on the microphones can be quickly seen and the best adjustment readily made.

The equipment has also been used to check new models of microphones, to measure the response and directional pattern of monitor loudspeakers, and for miscellaneous measurements, such as finding the transmission loss of loudspeaker grille cloth. If in the future a free-field room should become available the equipment can be used as it stands, simply by not using the pulsing switches. The equipment can also be readily adapted for more general laboratory purposes, such as measuring and plotting the response of filters or pickups.

Editor's Note—This paper was completed shortly before the death of the author, and was forwarded to ELECTRONICS by William G. Richardson, Transmission and Development Engineer with Canadian Broadcasting Corporation in Montreal.

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(1) Frank Massa, Working Standard for Sound Pressure Measurements, *Journal of the Acoustical Society of America*, vol 17, p 29, 1945.

(2) Walter Ives, A Logarithmic Indicating Instrument for the Measurement of Radio Noise Voltages, Master's Thesis at McGill University, Sept. 1946.

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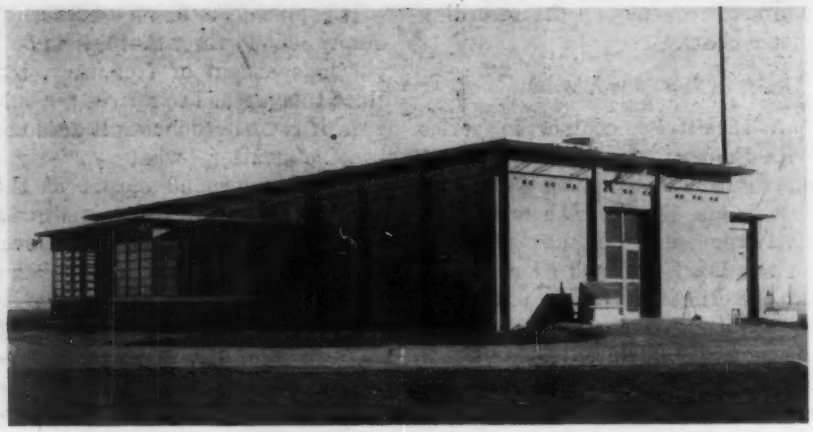
Design of a Naval Communication



Exterior of Dixon, California station. Holes under cornice are for feeders

New unit planned for pleasing appearance, operation by minimum of personnel, and capable of rational expansion stands at hub of rhombic array system. Deterioration of reinforced concrete structure is inhibited by novel method of bonding the rods

TO SET the best possible example in its postwar construction, the Office of the Assistant Chief of the Bureau of Ships for Electronics, in cooperation with the Bureau of Yards and Docks, has attempted to evolve a basic layout for the United States Naval Radio Transmitting Station at Dixon, California, which will function with a minimum number of personnel, provide low maintenance cost, and solve all probable expansions in the future.

The building expresses a definite architectural character rather than a box-like interpretation, by locating the columns which support the roof loads on the outside of the exterior wall, on centers of about 13 by 40 feet. This arrangement provides for a clear wall surface on the interior of the building and allows for ease of cleaning and lowered maintenance cost. It provides unobstructed maximum working area around the transmitters, and makes possible the running of transmission lines without any obstructions whatsoever within the transmitting room.

In order to obtain a flexible arrangement for routing incoming transmission lines to the various transmitters, seventy-five pairs of entering insulators are located beneath the protecting cornice of the building. Thus, a line can be pulled tight and held fast on the transmission line anchor, then looped under the cornice and into the feed-through insulator.

Internal Wiring

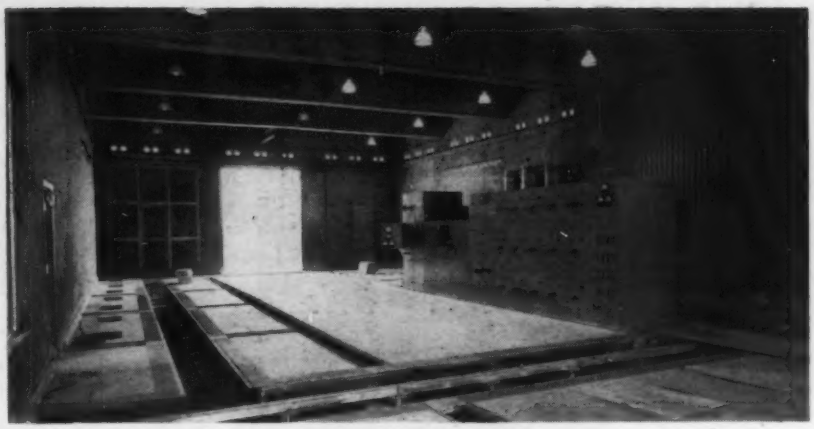
Cableways are used for cable, conduit, bus bars, piping, and the like, in lieu of an alternate design which would have necessitated that the transmission room be on a second floor, with access to cables arranged in continuous hangers from the ceiling below. Low cost in installing cable is made possible by the ease with which it can be rolled off reels over the main cableways without moving any equipment to do so. The equipment is installed directly over an adjacent system of small feeder trenches.

The floor material finish is terrazzo, ground smooth and divided into squares. The brass strips ordinarily used for dividing terrazzo could prove electrically dangerous to the personnel in the transmitter room, so plastic strips are used instead. Contrasted with a painted concrete surface, battleship linoleum, or asphalt tile, terrazzo fully meets the need of a good wearing surface capable of resisting heavy loads, and is easily maintained and kept clean.

Trucks for carrying equipment for the initial installation or any emergency find easy access through large aluminum sliding end doors. An overhead rail for supporting a hoist is utilized over the end bays of the transmitter room. Thus, equipment is lifted from a truck by means of the hoist to a hand-steered electric-powered transporter.

Air Conditioning

This windowless building, save for the administrative portion and the lavatory, is ideal for air conditioning. In addition, it keeps the building insect-proof, a vital consideration, because bugs have a tendency to work their way into transmitter equipment. The out-



Interior showing main switchgear, main and branch cable runways with covers removed

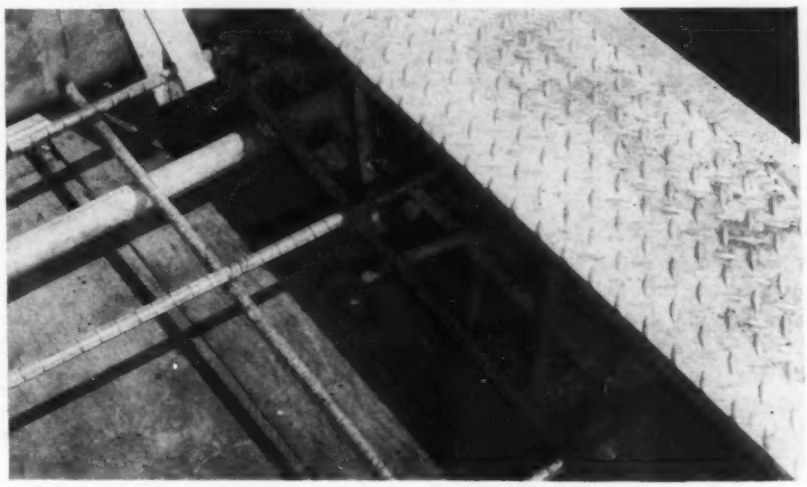
Station

side wall acts as a blast-resisting surface and the inside face provides a good light-reflecting surface.

In the normal course of operation, sufficient heat is generated by the transmitters to heat the building. This warm air is therefore recirculated and utilized for heating, being tempered by cool fresh air. A cooling system for warm weather utilizes the same duct system. The air in the ducts is maintained at a constant 70 to 75 degrees in the summer and winter. In the event of a transmitter shutdown, a boiler is provided as an auxiliary source of heat. Controls provide for automatic operation.

Designed for construction when future commitments so require is a vhf and shf tower which will be located over the loading platform at the rear. The cantilever floor of the tower provides a 360-degree area for spacing line-of-sight link antennas of the parabolic-reflector type.

Antenna switching will be accomplished by a system of handwheel switches that may later be remote controlled. The completed unit will be suspended from cross members framed into sidewall angles or channels in lieu of suspending the units from the ceiling or concrete girders.



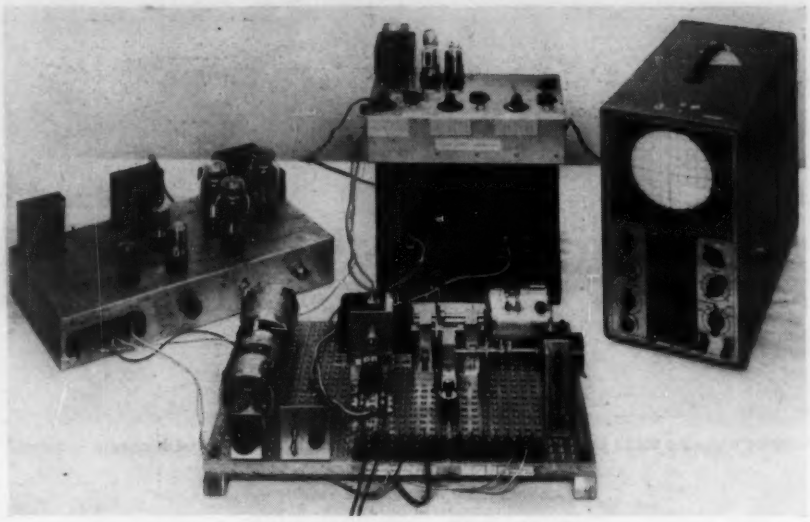
Detail of brazed bonds between reinforcing rods, structural members and conduit

The antenna arrangement consists of a number of rhombic transmitting antennas erected circularly from the transmitter building. The antennas are oriented in the specific direction in which the maximum signal is desired. The transmission lines run directly from the antenna to the antenna switching system, so that any transmitter can be connected to any transmission line. The transmission lines are 600-ohm open-wire type. The transmission-line anchors form an integral part of the building cornice design and, together with the antenna feed-through insulator, give the radio transmitting station its definite character.

Some previously erected reinforced concrete transmitting buildings have suffered partial disintegration owing to expansion of reinforcing rods at a rate faster than that of the concrete surrounding them. This heating was caused by absorption of stray radio-frequency energy. Appreciable energy can be picked up by rods that are resonant at full, half, or quarter wavelengths. Negligible energy is picked up at an eighth wave or less.

Grounding

Since the shortest wave at which appreciable power is to be radiated at the station is 12 meters, only ungrounded rods above 5 feet in length needed special treatment. Accordingly, all steel reinforcing rods are rigidly and continuously bonded to ground by arc welding or brazing. In addition, bonding wires are provided to ground as a precaution against breakage of the rod junctions during the vibrating of the concrete in the molds. Metal doors, window frames, and the like are bonded to the reinforcing steel. Conduit is tied in at least every 20 feet. All mechanical equipment is grounded separately with No. 6 or larger copper wire. The grounding system in the cableways consists of a network of $\frac{1}{8} \times 2$-inch copper bars. Ground rods are $\frac{3}{4} \times 10$-foot copper-covered steel with No. 2/0 stranded copper cable for connection to the reinforcing steel. This system is then tied in with the external underground network surrounding the station, and used with the antenna systems.



Laboratory equipment used in determining feedback constants includes the uncompensated servo (foreground), its amplifier (left), the adjustable feedback circuit whose parameters are to be found (background), and an oscilloscope

Stabilizing Servomechanisms

By this laboratory technique, constants of feedback stabilization circuits for servomechanisms can be quickly determined without resorting to mathematical computations, thus making it feasible to design and adjust servos for heretofore impracticable applications

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DEVELOPMENT of new techniques for improving the response of servomechanisms has made it possible to apply them to an ever increasing number of uses. These techniques are based upon: (1) improved methods of analysis which show the factors that limit servomechanism response, and (2) the design, or redesign, of components which improve the response.

This article describes a new and simple method for designing stabilization circuits which may be used to improve servomechanism response, and offers a new approach to the design of stabilization circuits in general. The design of these stabilization circuits is based upon the principle that *a circuit, having a transfer function which is the inverse of the transfer function of the servomechanism, can be used as a stabilization network, and that this circuit can be approximated by a feedback amplifier having in its feedback path a network with a transfer function proportional to that of the servomechanism.*

Consequently the first step in obtaining such a stabilization circuit is to design a circuit having a transfer function proportional to the transfer function of the unimproved servomechanism. This latter circuit will be referred to as the equivalent servomechanism circuit or the equivalent circuit.

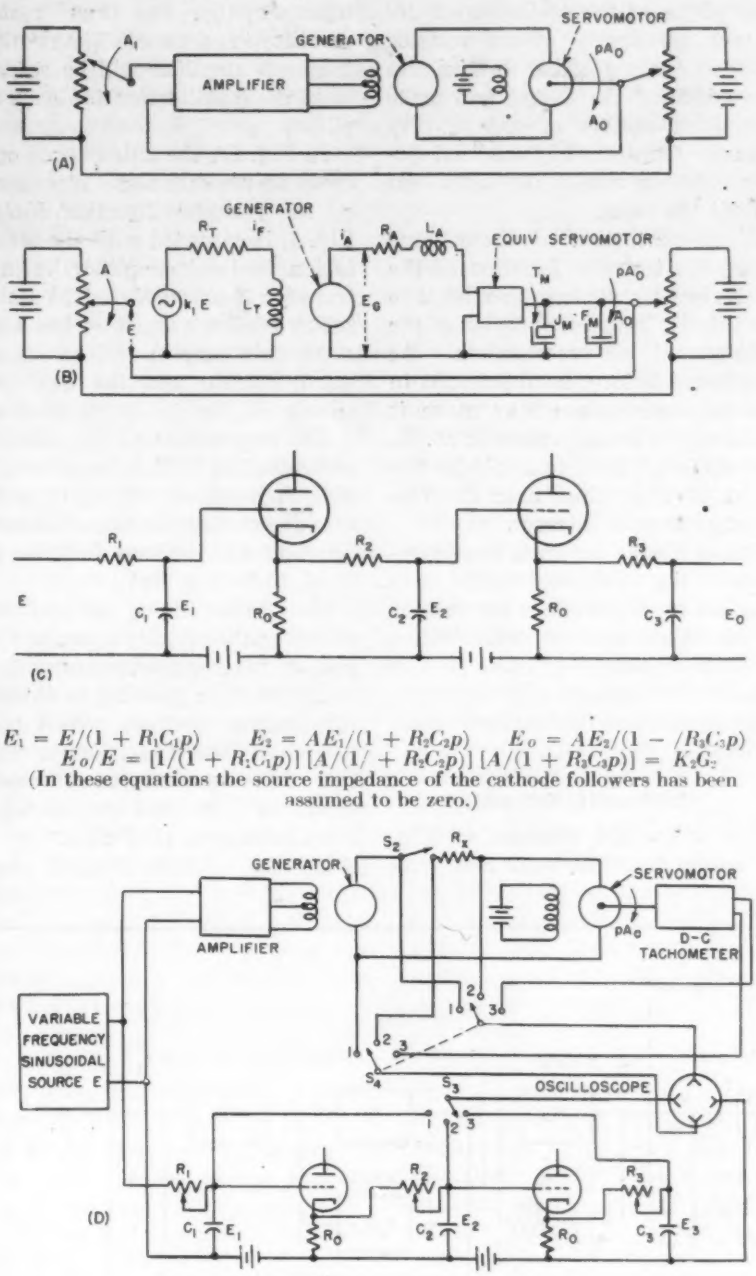
Obtaining Equivalent Circuit

The first step in designing the equivalent circuit is to set up the general form of the equivalent network. The second step is then to determine the parameters of this network. These two steps are illustrated by the examples of Fig. 1.

In Fig. 1A is shown the schematic of a simple servomechanism, using a motor-generator set as a power control component of the servomechanism. Figure 1B is the approximate electromechanical equivalent of Fig. 1A. Transfer functions of the system are expressed by the equations. This approximation is justifiable for the operating range of interest because, in general, the armature circuit time constant is short compared to the rotor time constant.

Figure 1C shows the general form of an electrical network having a transfer function of the same type as the velocity transfer function of the servomechanism. Comparison of the analytical expressions for the transfer function of the equivalent circuit of Fig. 1C, and for the servomechanism, demonstrates the equivalence of the network. The approximation in Fig. 1B was made so that the circuit of Fig. 1C could be composed only of R-C networks, thus simplifying the adjustment of the circuit of Fig. 1D.

Figure 1D is a schematic of the setup used in determining the values of the parameters of the equivalent circuit. This setup consists of the unimproved open-cycle servomechanism, the equivalent circuit, a variable-frequency sinusoidal-voltage source, a d-c tachometer, and an oscilloscope having d-c amplifiers to drive its deflection plates.



$$E_1 = E/(1 + R_1C_1p) \qquad E_2 = AE_1/(1 + R_2C_2p) \qquad E_0 = AE_2/(1 - /R_3C_3p)$$
$$E_0/E = [1/(1 + R_1C_1p)]\,[A/(1/ + R_2C_2p)]\,[A/(1 + R_3C_3p)] = K_2G_2$$

(In these equations the source impedance of the cathode followers has been assumed to be zero.)

$$i_F = \frac{K_TE/R_T}{1 + (L_F/R_T)p}$$

$$E_G = K_Fi_F$$

$$i_A = \frac{E_G/R_A}{1 + (L_A/R_A)p}$$

$$T_M = K_Mi_A$$

$$T_M = [1 + (J_M/F_M)p]\,F_MpA_0$$

$$pA_0/E = \frac{K_T/R_T}{1 + (L_F/R_T)p} \cdot \frac{K_A/R_A}{1 + (L_A/R_A)p} \cdot \frac{K_M/F_M}{1 + (J_M/F_M)p}$$

$K_1'G_1'$ = pA_0/E: velocity transfer function

K_1G_1 = A_0/E: transfer function

K_1G_1 = $K_1'G_1'/p$, where $p = d/dt$

J_M: moment of inertia of motor

F_M: equivalent damping coefficient of motor

R_A: resistance of generator and motor armatures

L_A: inductance of generator and motor armatures

L_F: inductance of generator field

R_T: equivalent source resistance of amplifier and field

K_T, K_A and K_M: constants of proportions

K_1' and K_1: real gain factors of transfer functions and are not a function of frequency

G_1' and G_1: complex factors of transfer function and are functions of frequency

FIG. 1—Method is based on theoretical comparison of servo (A) and (B) with feedback circuit (C). By adjusting the responses of the two systems to be the same (D) proper compensation is obtained

(This setup, in a simplified form, was first developed by the author in 1945 while a member of the MIT Servomechanisms Laboratory.)

With switch S_2 open, the selector switches S_3 and S_4 in position 1, the voltage E_1 of the equivalent circuit and the open-circuit output-voltage E_G of the generator are placed across the deflection plates of the oscilloscope. By adjusting resistor R_1, it is possible to reduce the elliptical figure on the oscilloscope screen to a straight line. Then the first factors of the velocity transfer functions of the actual servomechanism and of the equivalent circuit are the same.

In essence, when the ellipse becomes a straight line, the phase shift of the first stage of the equivalent circuit has been made equal to the phase shift of the first stage of the actual servomechanism. Therefore, the first factors of the velocity transfer functions of the actual servomechanism and of the equivalent circuit are the same because the servomechanism contains only minimum phase networks.

The frequency of the variable-frequency sinusoidal-voltage source should be varied over a large frequency range to insure that the first factors of the velocity transfer

functions of the actual servomechanism and of the equivalent circuit are the same for all frequencies. Nonlinearities in the servomechanism may make it impossible to obtain one value of R_1 which reduces the elliptical figure to a straight line for all frequencies. If this occurs, then that value of R_1 which minimizes the width of the ellipse over the frequency range of interest should be chosen.

With switch S_2 closed, selector switches S_3 and S_4 in position 2, and with the rotor of the servo motor locked, the voltage E_2 of the equivalent circuit and a voltage proportional to the current i_4 of Fig. 1B are placed across the deflection plates of the oscilloscope. By adjusting resistor R_2 it is possible to reduce the elliptical figure to a straight line, whereupon the second factors of the velocity transfer functions of the actual servomechanism and of the equivalent circuit are the same.

In a similar fashion, with switch S_2 closed and selector switches S_3 and S_4 in position 3, the voltage E_3 of the equivalent circuit and a voltage proportional to pA_0 of the servo motor are placed across the deflection plates of the oscilloscope. By proper adjustment of the resistor R_3 it is again possible to minimize the width of the ellipse and make the third factors of the velocity transfer functions of the actual servomechanism and of the equivalent circuit the same.

Upon conclusion of these three steps, the transfer function of the equivalent circuit is proportional to the velocity transfer function of the unimproved servomechanism. As mentioned before, nonlinearities in the servomechanism may make it necessary to choose values of R_1, R_2, and R_3 which tend to minimize the width of the ellipse over the frequency range of interest.

From simple network considerations of the equivalent circuit, it is possible to determine what factors in the unimproved servomechanism limit its response. If these factors cannot be removed by redesign, then a stabilization network must be used.

Stabilization Network

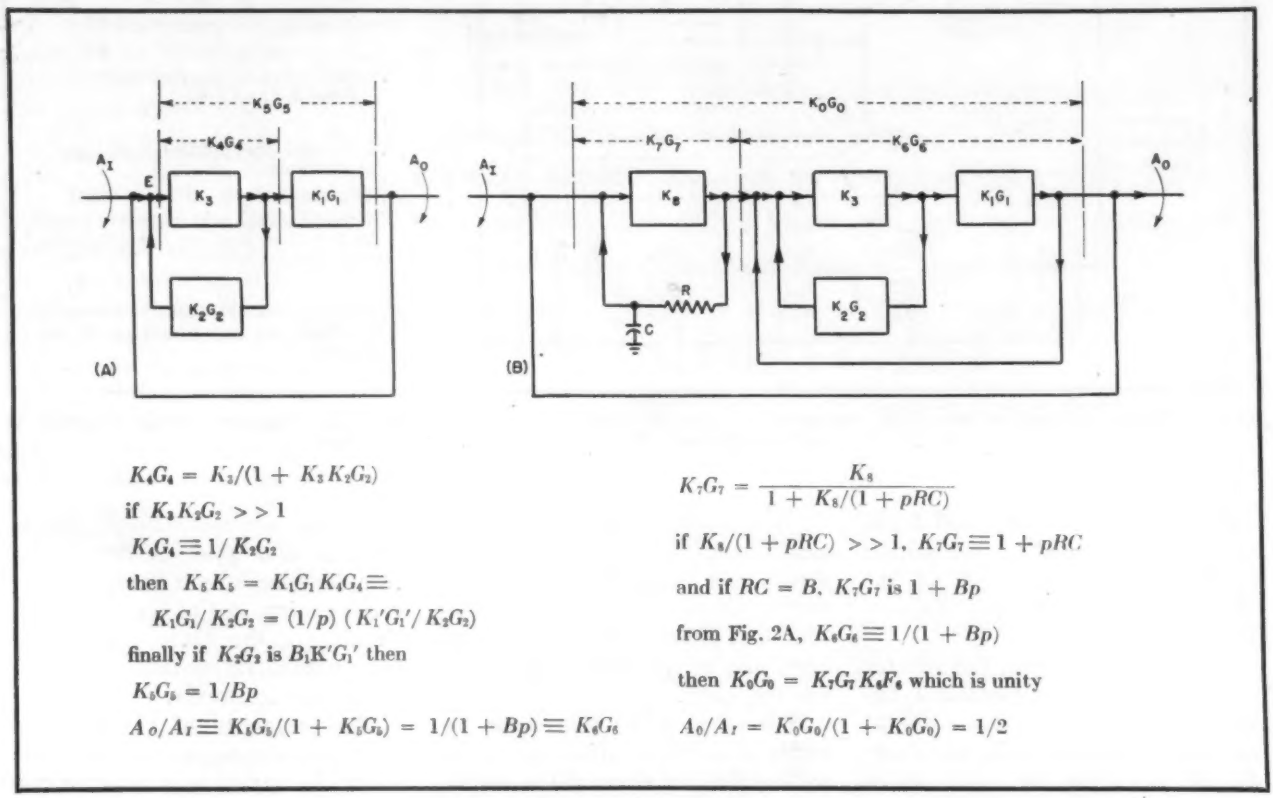
The schematic diagram of Fig. 2A shows how the equivalent circuit can be incorporated into a feedback amplifier and thus create a stabilization network. The resulting feedback amplifier will be referred to as the stabilization feedback amplifier.

In Fig. 2A the unimproved open-cycle servomechanism, represented by the transfer function K_1G_1 of Fig. 1, is cascaded with the stabilization feedback amplifier having a transfer function K_4G_4. The stabilization feedback amplifier has a constant gain amplifier K_3 in its forward branch, and the equivalent circuit of Fig. 1C in its feedback.

The expressions of Fig. 2A demonstrate that if K_3 is large enough, K_4G_4 approaches $1/K_2G_2$. It is further shown that the overall transfer function K_5G_5 reduces to $1/Bp$ and A_0/A_I to $1/(1 + Bp)$.

Thus by combining the equivalent circuit of the velocity transfer function of a servomechanism with an amplifier, it is possible to obtain a stabilization network which tends to reduce both the transfer function of the compensated servomechanism to $1/Bp$, and the output-to-input ratio to $1/(1 + Bp)$.

If the output-to-input ratio



$K_4G_4 = K_3/(1 + K_3K_2G_2)$

if $K_3K_2G_2 >> 1$

$K_4G_4 \equiv 1/K_2G_2$

then $K_5K_5 = K_1G_1K_4G_4 \equiv$

$K_1G_1/K_2G_2 = (1/p)\ (K_1'G_1'/K_2G_2)$

finally if K_2G_2 is $B_1K'G_1'$ then

$K_5G_5 = 1/Bp$

$A_0/A_I \equiv K_5G_5/(1 + K_5G_5) = 1/(1 + Bp) \equiv K_6G_6$

$$K_7G_7 = \frac{K_8}{1 + K_8/(1 + pRC)}$$

if $K_8/(1 + pRC) >> 1$, $K_7G_7 \equiv 1 + pRC$

and if $RC = B$, K_7G_7 is $1 + Bp$

from Fig. 2A, $K_6G_6 \equiv 1/(1 + Bp)$

then $K_0G_0 = K_7G_7K_6F_6$ which is unity

$A_0/A_I = K_0G_0/(1 + K_0G_0) = 1/2$

FIG. 2—When necessary, additional feedback loops can be added by the basic technique. The experimental method helps to assure that the circuit parameters of the multiloop system will not produce oscillation

A_o/A_i of the compensated servomechanism of Fig. 2A is considered to be a transfer function K_6G_6, it is possible to design an equivalent network for this transfer function. This equivalent network may be obtained by comparing K_6G_6 to a single R-C stage in a manner similar to that demonstrated in Fig. 1D.

This single stage equivalent R-C network can be used as the feedback branch of a stabilization feedback amplifier and the resulting feedback amplifier cascaded with K_6G_6, as shown in Fig. 2B. If this is done, the expressions of Fig. 2B show that K_7G_7, the transfer function of this stabilization feedback amplifier, approaches $1+Bp$, and the overall transfer function K_6G_6 of the twice-compensated servomechanism approaches unity. Therefore, in the limit, A_o becomes directly proportional to A_i. Although not shown schematically in Fig. 2, the gain of the system can be increased with the application of the principle outlined above.

In the examples of Fig. 2, it was assumed that the transfer function K_6G_6 approached $1/(1 + Bp)$ and that, therefore, the R-C product of the equivalent circuit of K_6G_6 should equal B. In general, it may not be possible to reduce K_5G_5 to exactly $1/Bp$, and therefore K_6G_6 will be slightly more complex than $1/(1 + Bp,)$. Consequently, when comparing the equivalent R-C network to K_5G_5, a value of R should be chosen which tends to minimize the width of the ellipse over the frequency range of interest.

Figure 2 shows that it is possible to enhance the stability of a servomechanism by first cascading the open-cycle servomechanism with a stabilization feedback amplifier containing the equivalent circuit of its transfer function, and then by closing the servo feedback loop around these two cascaded components. This procedure may be repeated successively until the desired improvement in the response of the servomechanism has been achieved.

Practical Considerations

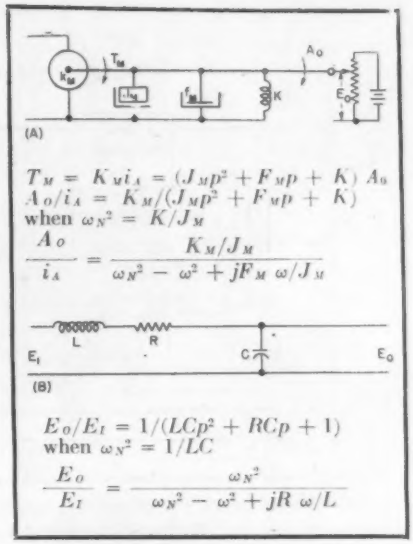
In any servomechanism it may not be necessary to compensate for every time delay or its equivalent. Consequently, the equivalent circuit used in the stabilization feedback amplifier need not always contain all of the terms of the complete velocity transfer function. In fact, it may be more practical not only to reduce the number of terms in the equivalent transfer function, but also to approximate the remaining ones.

Following this philosophy, an approximate equivalent circuit can be designed which is composed of only one or two R-C networks or an RLC network. With the setup of Fig. 1D these R-C or RLC networks can be made equivalent for only those frequencies where the maximum phase shift and resonance in the servomechanism response has been observed. Then an approximate stabilization feedback amplifier can be constructed, and the procedure of Fig. 2A gollowed. The remaining uncompensated factors which limit the response of the servomechanism can either be neglected, or removed, by another approximate equivalent circuit and stabilization feedback amplifier, as was done in Fig. 2B.

The number of cathode followers used in the equivalent circuit may be reduced if the impedance of one R-C network is several times greater than the impedance of the preceding network, thus making it unnecessary to isolate these two networks.

In some cases the inertia of the d-c tachometer of Fig. 1D, might be comparable to the inertia of the servomotor which would change the effective characteristics of the servomotor. If this condition arises, the d-c tachometer should be coupled to the motor through a gear reduction. This gearing down usually can be accomplished by coupling the d-c tachometer into the output gear train at some convenient gear mesh.

It is a worthwhile precaution, when combining the equivalent circuit with an amplifier, to form a stabilization feedback amplifier to use no more than two time constants, or their equivalent, in one feedback branch. Otherwise the possibility exists that the stabilization feedback amplifier may oscillate itself. If there are more than two time constants, or their equivalent, in an equivalent circuit, then



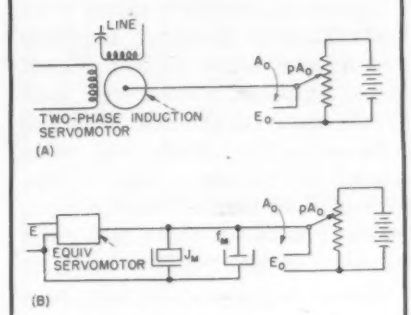
$T_M = K_M i_A = (J_M p^2 + F_M p + K)\, A_o$
$A_o/i_A = K_M/(J_M p^2 + F_M p + K)$
when $\omega_N^2 = K/J_M$

$$\frac{A_o}{i_A} = \frac{K_M/J_M}{\omega_N^2 - \omega^2 + jF_M\,\omega/J_M}$$

$E_o/E_I = 1/(LCp^2 + RCp + 1)$
when $\omega_N^2 = 1/LC$

$$\frac{E_o}{E_I} = \frac{\omega_N^2}{\omega_N^2 - \omega^2 + jR\,\omega/L}$$

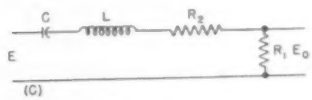
FIG. 3—Spring loaded servos can be compensated by an additional step in the method



$T_M = K_3E = (1 + J_M p/F_M)\, F_M p A_o$

$$pA_o/E = \frac{K_3/F_M}{1 + J_M p/F_M} = K_1'G_1'$$

where $p = d/dt$
J_M: moment of inertia of motor
F_M: equivalent damping coefficient of motor



R_2 is self resistance of L
$E_o/E = ARCp/(LCp^2 + RCp + 1)$
where $R = R_1 + R_2 = R_2/A$
which becomes, on a frequency basis,
$E_o/E = jARC\,\omega/(1 - \omega^2\,LC + jRC\,\omega)$ if $LC = 1/\omega_c^2$
where ω_c is carrier frequency and
$\omega = \omega_c \pm \omega_s$

$$\frac{E_o}{E} = \frac{jARC\omega_c\left(\frac{\omega_c \pm \omega_s}{\omega_c}\right)}{1 - \frac{(\omega_c \pm \omega_s)^2}{\omega_c^2} + jRC\omega_c\left(\frac{\omega_c \pm \omega_s}{\omega_c}\right)}$$

if $\omega_s << \omega_c$
$E_o/E = A/(1 \pm j2\,\omega_s/RC\,\omega_c^2)$

FIG. 4—Alternating-current servomechanisms can be handled similarly to d-c ones, but see Fig. 5

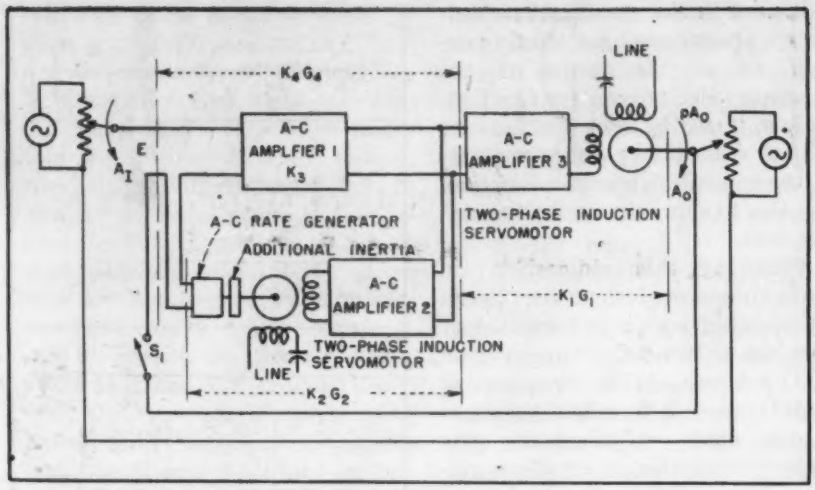


FIG. 5—Stabilizing a-c servos can be simplified if a motor-generator set is used in the feedback path instead of a passive network

several stabilization feedback amplifiers should be used.

Good results can be obtained from a stabilization feedback amplifier with a value of K_3, in Fig. 2A, of only 7 to 10. The overall gain K_4 of the stabilization feedback amplifier can be made any value desired by proper choice of the value of K_2 of the equivalent circuit. It is worth noting that the amplifier K_3 does not have to be an additional amplifier, but may be a stage of K_4.

Case of Spring Loading

In many applications the output motion of the servomotor is restrained by a spring, as in the case of a torque servomotor actuating the pilot valve of a hydraulic system. Figure 3A shows the electromechanical circuit of a servomotor restrained by a spring of stiffness K, and Fig. 3B shows its equivalent circuit. In this example the servomechanism amplifier stages are not shown, and the servomotor is assumed to operate on d-c.

The output voltage E_o of the equivalent circuit may be made proportional to the output voltage E_o of the physical system in a manner similar to that demonstrated in Fig. 1D. In this case it is not possible to subdivide the equivalent circuit or the electromechanical circuit so that only one variable may be adjusted, or compared, at a time. This difficulty may be overcome by noting that at high frequencies the voltage E_o is primarily a function of the L-C product, and that at low frequencies it is primarily a function of the R-C product. Therefore, with the frequency of the variable-frequency sinusoidal-voltage source high, C should be adjusted until the width of the ellipse has been minimized. Then the frequency should be reduced until the width of the ellipse is quite large. At this frequency the value of R should be adjusted until the width of the ellipse has again been minimized. Estimate of approximate value of L and C may be obtained by visual observation of natural frequency of unexcited servomotor and spring.

So far, the servomechanisms described have been d-c types. Figure 4A shows part of a two-phase induction motor servomechanism and Fig. 4B its electromechanical equivalent. The amplifier components have not been considered because, in general, straightforward amplification stages act upon the sidebands of the modulated suppressed-carrier signals and therefore produce only very small time delays. On the other hand, the servomotor essentially demodulates the modulated suppressed-carrier signal and acts only upon the envelope or modulating signal, and thus may produce large time delays.

Compensating A-C Servos

Figure 4C is a schematic of the equivalent circuit of the two-phase induction servomotor. As will be noted from the analytical expressions of Fig. 4C, the equivalence of this circuit holds only over a limited region of the modulating signal frequencies. This situation is generally true of any a-c network containing only linear elements.

The parameters of this equivalent circuit may be determined by the procedure demonstrated in Fig. 1D. As there are two variables, L and R to be adjusted together, tuning L and C so that they resonate at the carrier frequency leaves only R to be adjusted.

As mentioned before, the a-c servomotor demodulates the modulated suppressed-carrier signal, and, therefore, it is difficult with linear elements to synthesize a network which is the equivalent of the a-c servomotor. This factor makes it quite difficult to obtain as much stabilization from linear a-c networks as from linear d-c ones. It is, therefore, suggested that a small two-phase motor, directly coupled to a small a-c rate generator, be used as the equivalent circuit for an a-c servomechanism. This small two-phase motor and generator combination can then be used as the feedback branch of a stabilization feedback amplifier, and the resulting amplifier will serve as a stabilization network for two-phase servomechanisms. Figure 5 demonstrates the method by which this may be accomplished.

The a-c amplifier No. 2 of Fig. 5 does not need to be a separate amplifier, but may be a stage from either K_2 or a-c amplifier No. 3. A velocity signal proportional to the signal developed by an a-c rate generator can be obtained from the control phase of the small two-phase motor and thus eliminate the a-c rate generator from the circuit (see Fig. 5).

In review, the response of a servomechanism can be improved with the aid of an approximate stabilization feedback amplifier (Fig. 1D). Furthermore, if the response is not sufficiently improved after the use of a single stabilization network, additional networks may be added. The design of these additional networks usually is simplified by the use of a minor feedback loop around the first stabilization network and the unimproved servomechanism which are in cascade. This effect is demonstrated in Fig. 2B.

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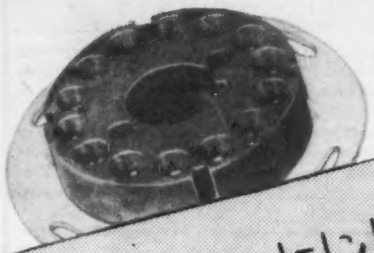

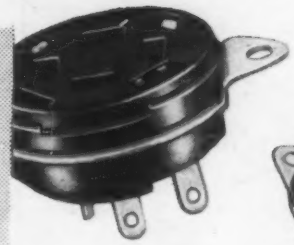

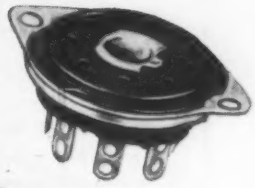

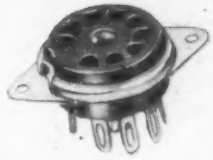

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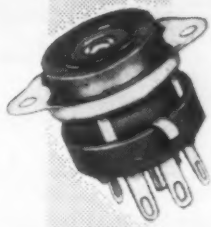

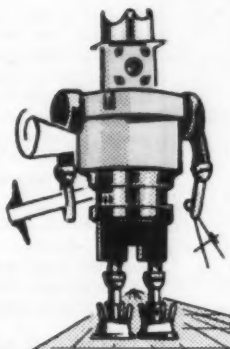

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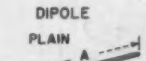
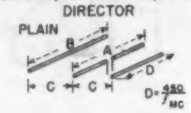
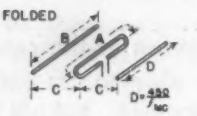
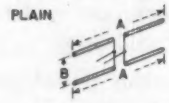
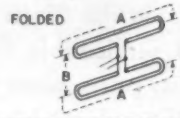
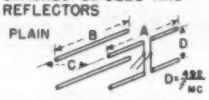
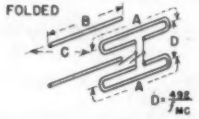
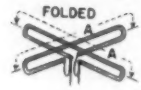
DIPOLE PLAIN  FOLDED 	72 390	Figure of eight, bidirectional broadside to elements	Circular	Unity	Zero	PLAIN—75-ohm coaxial. FOLDED—300-ohm twin-lead. Use of twin-lead to feed plain dipole gives broadband operation but extreme loss in gain; not recommended General two-direction coverage for receiving in areas of moderate signal strength. Folded dipole slightly more broadbanded than plain. If 300-ohm twin-lead is used as radiator, do not shorten length A for propagation factor
DIPOLE AND REFLECTOR PLAIN FOLDED 	60 250	Unidirectional broadside to radiator	Half of figure of eight	2 to 2½ times	3 to 4 db	PLAIN—50-ohm or 75-ohm coaxial; 75-ohm cable is more broadbanded. FOLDED—300-ohm twin-lead Single-direction coverage, high front-to-back ratio and high gain. Recommended for use in areas of low signal strength and where single-direction radiation pattern is desired. Folded radiator slightly increases bandwidth. If array is to be used over narrow band, calculate length B at lowest frequency desired. Reducing C to 0.15 λ (in air) gives higher gain but lowers impedance and reduces bandwidth
DIPOLE, REFLECTOR, AND DIRECTOR PLAIN  FOLDED 	20 to 30 80 to 120	Unidirectional broadside to radiator	Half of figure of eight	2½ to 4 times	4 to 6 db	PLAIN—50-ohm coaxial. If better impedance match is desired, use quarter-wave matching transformer; impedance of transformer should be square root of product of line and antenna impedances. FOLDED—75-ohm coaxial or 95-ohm twin coaxial Single-direction coverage, high front-to-back ratio and high gain. Very frequency-sensitive. Narrow bandwidth. Recommended for use in areas of very low signal strength and for one frequency only. Spacing is λ/4; reducing C to 0.15λ for reflector and 0.1λ for director (in air) increases gain but reduces impedance to 8 to 10 ohms for plain and 30 to 40 ohms for folded dipole
STACKED DIPOLES PLAIN  FOLDED 	35 to 40 150	Figure of eight, bidirectional broadside to elements	Figure of eight, bidirectional broadside to elements	2 to 2½ times	3 to 4 db	PLAIN—50-ohm coaxial. FOLDED—150-ohm twin-lead. Quarter-wave matching transformer may be used for 300-ohm twin-lead if desired, but will be frequency-sensitive High-gain array for use in areas of low signal strength and where two-direction coverage is needed. Useful over moderate frequency band. Value of B may be reduced to λ/8 (in air) if desired, with a reduction in gain
STACKED DIPOLES AND REFLECTORS PLAIN  FOLDED 	25 to 30 100 to 120	Unidirectional broadside to elements	Unidirectional broadside to elements	4 to 5 times	6 to 7 db	PLAIN—50-ohm coaxial cable. Quarter-wave matching transformer may be used for better impedance match but will be frequency-sensitive. FOLDED—95-ohm twin coaxial cable or 150-ohm twin-lead High-gain array for use in areas of low signal strength and where single-direction coverage is desired. Useful over relatively narrow band. Value of C may be reduced to 0.15λ (in air) with an increase in gain. Value of impedance will be lower and array will be more frequency-sensitive. Value of D may be reduced to λ/8 (in air) if desired, with a reduction in gain
TURNSTILE PLAIN FOLDED 	35 to 40 150	Circular. Radiation pattern changes with frequency	Figure of eight	0.7 of a dipole	−1½ db	PLAIN—50-ohm coaxial cable. FOLDED—150-ohm twin-lead Omnidirectional coverage for use in areas of high signal strength. Low gain. Very frequency-sensitive; radiation pattern approximates dipole pattern rotated 45° from axis of either dipole when operated off frequency. With this array, two dipoles are connected together with a quarter-wave phasing section of 75-ohm coaxial cable for plain dipoles and 300-ohm twin-lead for folded dipoles. Length of phasing section must be corrected for propagation constant of line used

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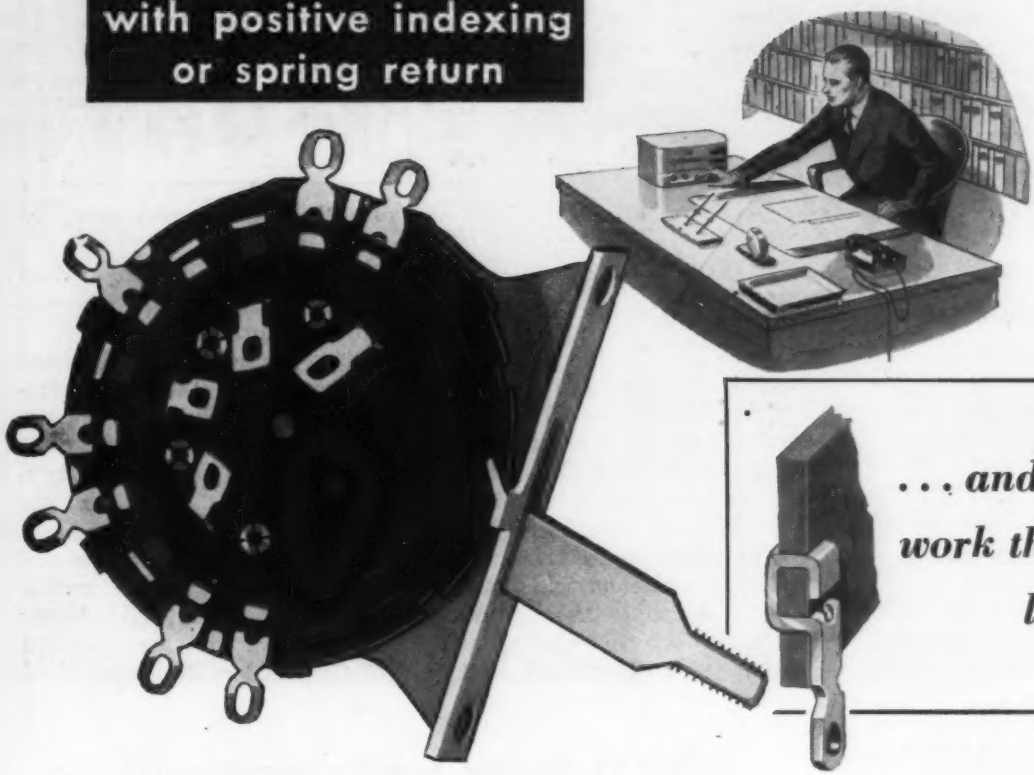

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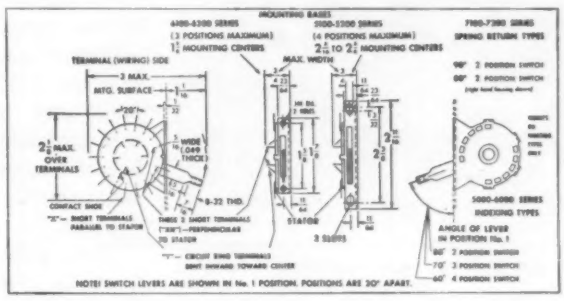
Although only recently developed and placed on the market, this lever action switch is in big demand. No wonder! It is ideally suited to intercommunications, centralized radio, sound distribution and public address equipment. It gives you a choice of positive indexing *or* spring return. It is as dependable as the leaf spring telephone type switch, yet available at much lower cost.

Consider some of the other "plus" features that set this switch apart: Self-holding terminals of exclusive design are securely clinched to the stator without rivets or eyelets (just try to pull them loose!). All terminals, contacts and ground rings are silver plated for low contact resistance. Constant tension of rotor contact members provides a dependable, self-cleaning action. Insulation is of the highest-grade phenolic.

Positive indexing types of this switch have 48 standard circuit combinations, 24 shorting and 24 positive non-shorting. Spring return types have 17 standard shorting and 17 positive non-shorting circuit combinations. Write for engineering data folder or see your nearest Mallory distributor.



Send for Engineering Data Folder

The Engineering Data Folder for the new Mallory Lever Action Switch contains complete specifications, available circuit combinations with respective terminal locations, dimensional drawings—everything the engineer needs to assist in selection of the particular Mallory Lever Action Switch to best handle the application.

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MALLORY SWITCHES

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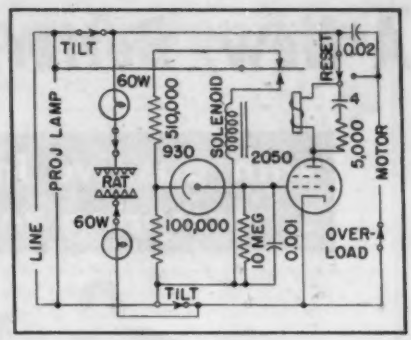
TUBES AT WORK

Including INDUSTRIAL CONTROL

Edited by VIN ZELUFF

Automatic Rat-Catcher Circuit 120
Pulsed Underwater Acoustic Measurements 120
Electronic Fuse 136
Improving Performance of Milliwatt Relays 140
Camera Shutter Timer 148
Telecontrolled Clocks 152
Sound Flashlight for the Blind 156

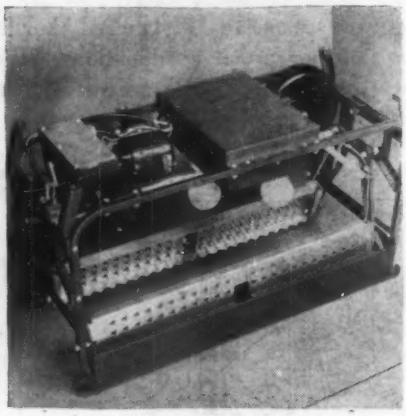


Circuit of the rodent electrocution machine

Automatic Rat-Catcher Circuit

AUTOMATIC electrocution of rats and other rodents is accomplished by the machine illustrated in the accompanying photograph. It is designed to be placed on a rat runway in a factory building in the food or other industry having a general sanitation problem.

The unit illustrated is normally contained inside a metal case that is open at each bottom end to provide the rat runway. When a rodent enters the runway he intercepts a beam of light from a projection lamp that shines into a phototube on the other side of the runway. The phototube triggers a 2050 thyratron, shown in the circuit diagram, which fires and energizes a relay that connects the line voltage to a solenoid. This in turn trips two metal grids having pointed projections and the grids snap together and hold the rat firmly.



View of the rat catcher with metal case removed to show the electronic and mechanical features

The grids are maintained at the voltage of the power line (through the series 60-watt lamps) and the potential is applied to the rat for a lethal period of about 120 seconds. When electrocution is completed, the rat is lifted, still held by the grids, to a door at the side of the metal case which opens to allow ejection. A motor-driven mechanism carries out this ejection and resetting cycle in 30 seconds. At the end of the cycle, the grids return to the ready or arming position and the ejection door closes.

During ejection, the plate voltage is removed from the 2050 thyratron and when the cycle is completed this connection is restored so that the tube is ready to be triggered by another pulse from the phototube, in turn caused by another rat. The technique is said to cause the rodent no pain, mutilation or freightened struggle by the manufacturers of the machine, LFC Corporation, Rochester, N. Y.

Pulsed Underwater Acoustic Measurements

BY GEORGE F. BREITWIESER

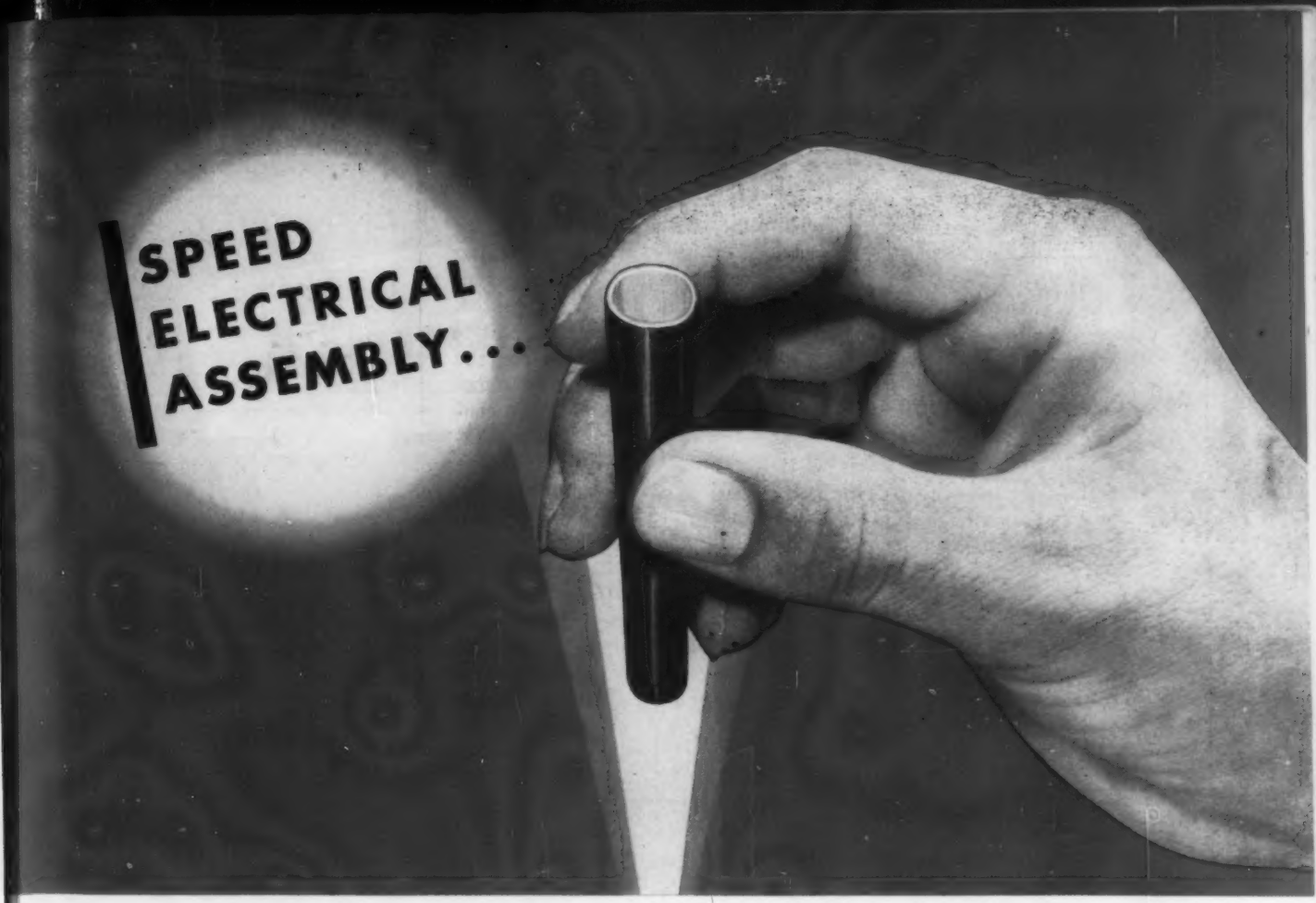
Acoustics Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

UNDERWATER acoustic measurements in laboratory tanks are sometimes complicated by interfering waves reflected from the walls. Unless the tank is lined with highly absorbing material, steady state measurements are difficult to make, because standing waves of significant amplitude are almost always present.

This difficulty can be avoided[1] however, if measurements are made by a pulse technique in the short time interval before unwanted reflections can reach the receiver. Such measurement of reflections from a steel plate is illustrated in Fig. 1.

A burst of acoustic power is projected into the tank. Echoes are formed when this burst strikes the plate and the walls and before long these echoes fill the tank with complex wave patterns. The condition required for measurements is shown in Fig. 1B. Here the outgoing burst has entirely passed, the echoes reflected from the walls have not yet reached the receiver, and the middle of the wave packet reflected from the plate is just at the receiver.

Figure 2 is a block layout of a reliable circuit which has been developed for making this kind of measurement. Only the useful middle section of the received signal is shown on an oscilloscope allowing the study of phase, amplitude, and wave shape of the reflected wave. The measurement cycle is repeated at a frequency which leaves time for reverberation to die out between bursts. Pulses formed at 60 cps from the a-c line actuate a submultiple generator which in turn delivers pulses at 10 to 60 per second. These pulses initiate the measurement cycle by controlling the transmitting and re-



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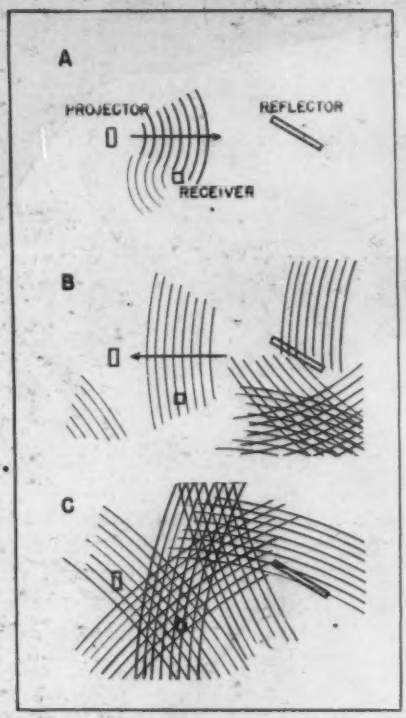


FIG. 1—Acoustic measurements incorporating the pulse technique are made only during interval (B) when only the desired reflected waves are at the receiver

ceiving systems and synchronizing the oscilloscope sweep circuit.

An initiating pulse acting on the oscillator control circuit creates a longer control pulse which actuates the oscillator. While on, the oscillator delivers a burst of power at its characteristic frequency. This burst, amplified in a conventional transmitting amplifier, is delivered to a transducer which then projects a sound pulse into the water.

After passing through the acoustic system, the wave packet is picked up by a hydrophone receiver, which feeds a signal into the receiver amplifier. A gate circuit is interposed between the output of this amplifier and the input of the oscilloscope. A delayed gate pulse is applied to the receiver gate circuit when the acoustic pattern in the tank has developed to the proper degree. The gate pulse allows the receiver to become operative only long enough to pass the desired section of the received signal.

It will be evident that full use has been made here of the pulse techniques used during the war in radar and sonar systems. From a practical point of view, phase and wave shape observations which were out of the question in previous acoustic pulsing equipment using electronic switch tubes can now be made, because variable switching transients and lack of phase synchronization have been eliminated.

The detailed schematic circuit is shown in Fig. 3. Except for the pulsed oscillator,[2] which is somewhat unusual, each section is a conventional circuit with constants adjusted for this application. These circuits are given in standard texts[3] and can be redesigned by well known methods[3,4,5] to fit other applications.

With circuit constants shown in the schematic diagram, burst repetition rates of 60, 30, 20, 15, 12, and 10 per second are possible. The burst duration is adjustable from 1 to 90 milliseconds, while the receiver gate pass duration is variable between 0.1 to 9 milliseconds. Acoustic frequencies from 17 kc to 50 kc are available, and the receiver gate time delay may be varied from 1 to 90 milliseconds. Any of these

(continued on p 136)

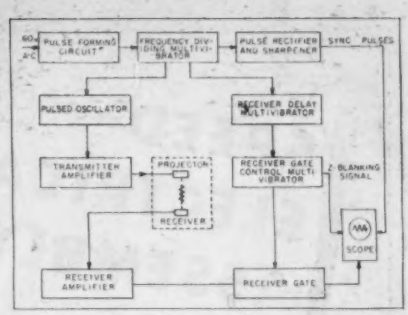


FIG. 2—Block diagram of acoustic pulse measurement equipment

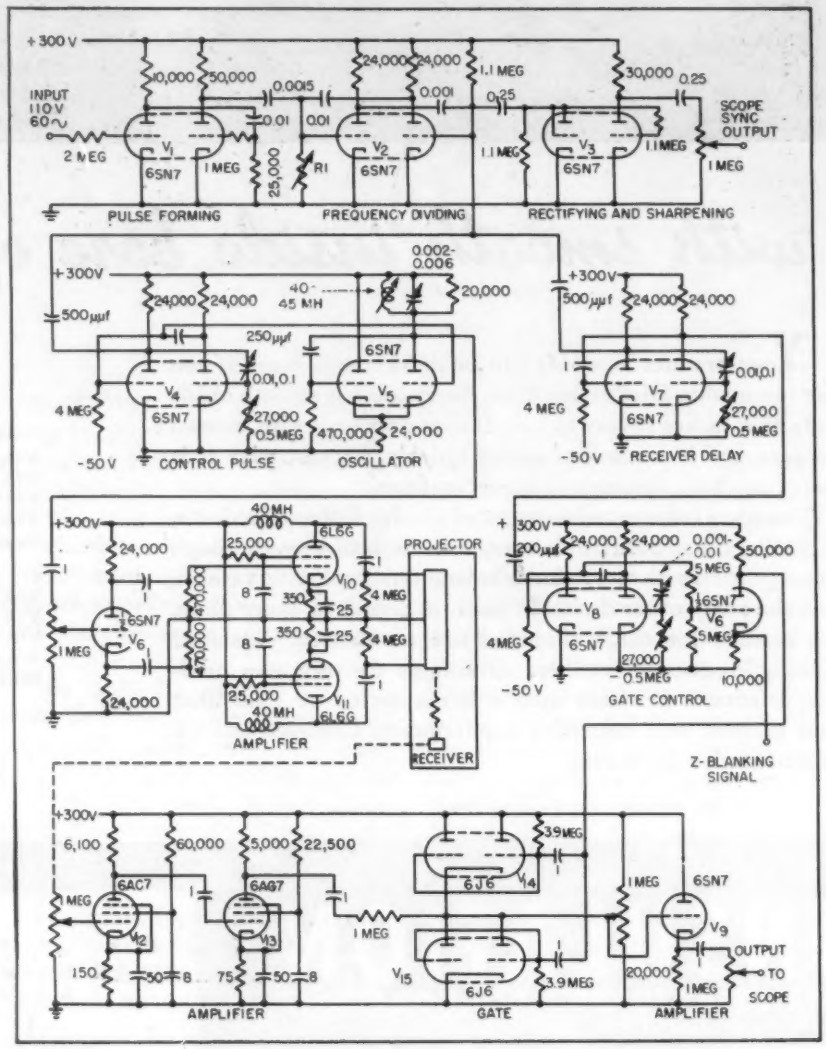
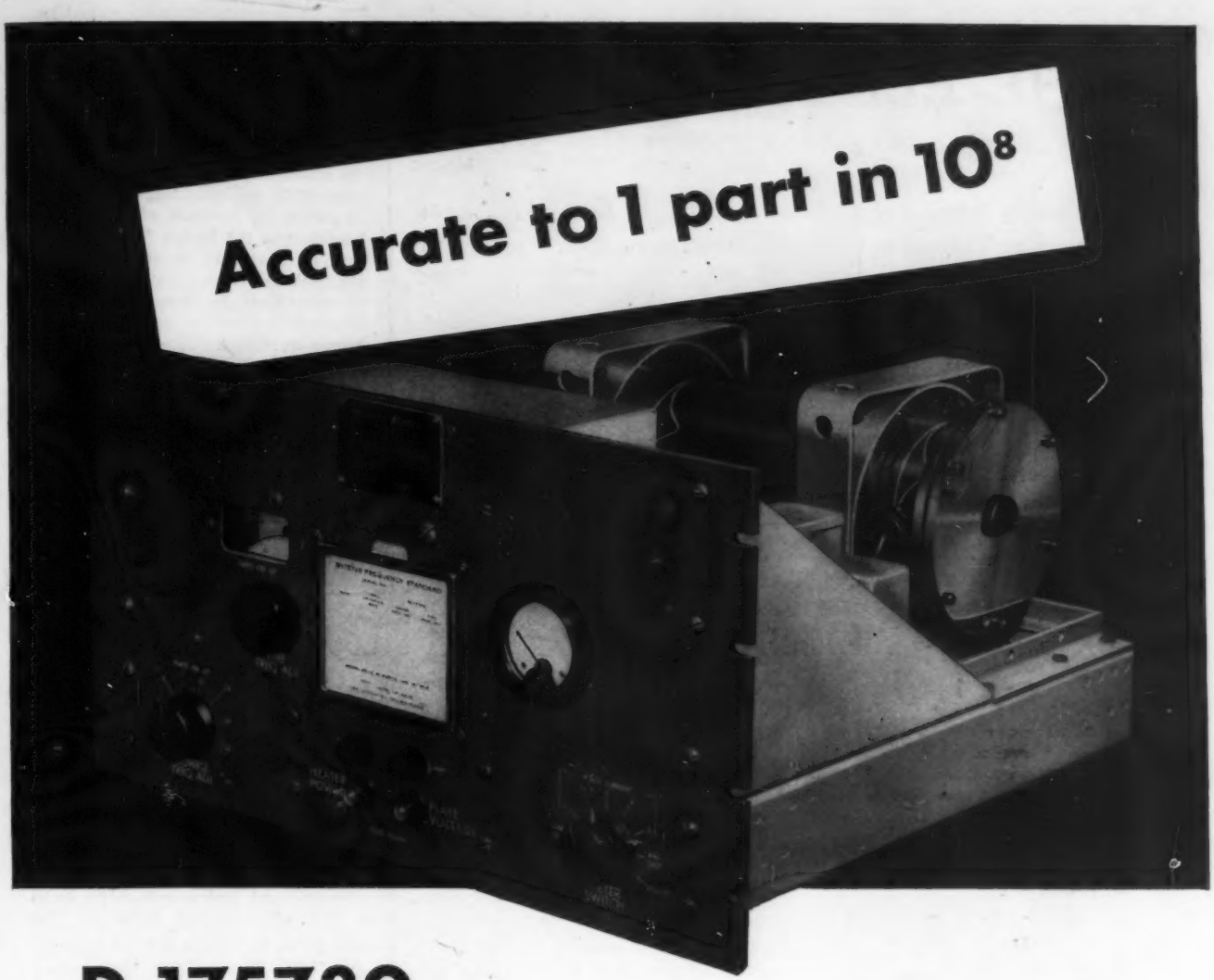


FIG. 3—Schematic diagram of acoustic measurement circuit using the pulse technique. Resistor R_1 is variable in steps of 0.75, 1.5, 2, 2.7, 4 and 5 megohms for selection of pulse repetition rates



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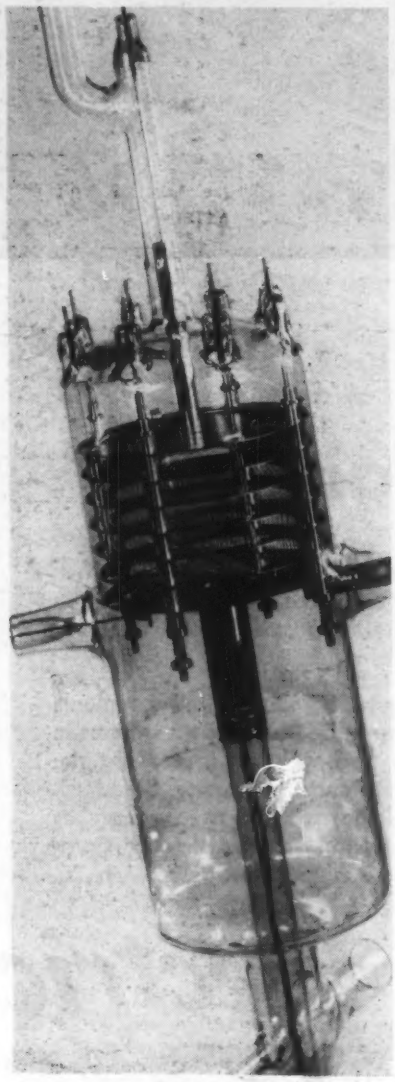
THE ELECTRON ART

Edited by FRANK ROCKETT

Radio-Frequency Mass Spectrometer 124
Noise in Vacuum Phototubes at High Current Levels 126
Detecting Displacement 168
Reducing Hum in Pentodes 170
Survey of New Techniques 178

Radio-Frequency Mass Spectrometer

A NEW TYPE ELECTRONIC TUBE, which provides a greatly simplified and flexible mass spectrometer, has been designed by W. H. Bennett of the National Bureau of Standards. The new spectrometer provides means of exploring the little-known fundamentals of negative atomic ions and a simple method for studying positive ions. The accompanying photograph shows the construction of a single-stage tube, which requires low direct biasing voltages and a radio-frequency voltage that can be varied from about 100 kc to 3 mc for its operation. In experiments with negative ions, a magnetic field of the order of 100 gauss parallel to the grids of the tube is also required.



New electronic tube makes practical the investigation of negative ions and simplifies equipment for studying positive ions

Formation of Negative Ions

Development of the new tube was necessitated by attempts to investigate conditions leading to the formation of negative atomic ions of the heavier elements. Detecting, separating, identifying and measuring such ions is one of the neglected fields of research in pure physics. These negative ions, consisting of atoms with extra electrons, have very low energies of formation; their study has been difficult because of their rapid dissociation in very short distances, before they reach a measuring electrode.

Since their discovery about 40 years ago, negative ions have been detected for only a few elements, although theory indicates that many elements should have such ions. Previous experiments at NBS indicated that negative ions might exist in many familiar forms of electronic tubes, but that they would not be detected if the discharge path within the tube was longer than about an inch.

Operation of Spectrometer

The radio-frequency mass spectrometer tube consists of a cathode, near which positive or negative ions are formed, several grids and a plate. If negative ions are to be studied, a small magnetic field is required to confine the electrons to the space inside the first grid to prevent formation of positive ions in other parts of the tube.

Ions arising at the cathode are accelerated through the first grid into the alternating field of the second grid, to which the r-f voltage is applied. Those ions that enter this field at the proper phase, and which have a mass and velocity related to the frequency of the field, pass through the second grid as the r-f potential changes polarity. Thus these ions are accelerated while traveling from the first to the third grid. A blocking potential, nearly equal to the maximum energy with which ions of the proper mass emerge from the r-f field, is applied to the fourth grid and the current to the plate is observed, thus indicating the rate at which ions of a particular type are being formed.

The method can be extended to two cascaded stages as shown in the following picture, thus obtaining a high order of mass resolution. In its more advanced form, this double-stage spectrometer can be used for measuring positive or negative ions. The equipment consists essentially of a multigrid tube in which the adjustable radio frequency is applied to two grids, one in each of the two stages, while all

CURE FOR RESIDUAL RIPPLE

Ripple introduced into high-gain balanced low-frequency amplifiers from the alternating heater currents can be removed by demagnetizing the tubes. In setting up hundreds of biological amplifiers at the Burden Neurological Institute (England), it was observed that although ripple could be reduced in some cases by using tubes with screened heaters or operating the heaters at reduced voltage, ripple from the magnetic component of the heater current remained in some tubes. Inasmuch as selection of tubes was impractical, some method for removing this source of ripple was sought. The investigation showed that this residual magnetic source of ripple could be removed by demagnetizing the tubes in a decreasing a-c field. (Electronic Engineer, p 235, July 1948)

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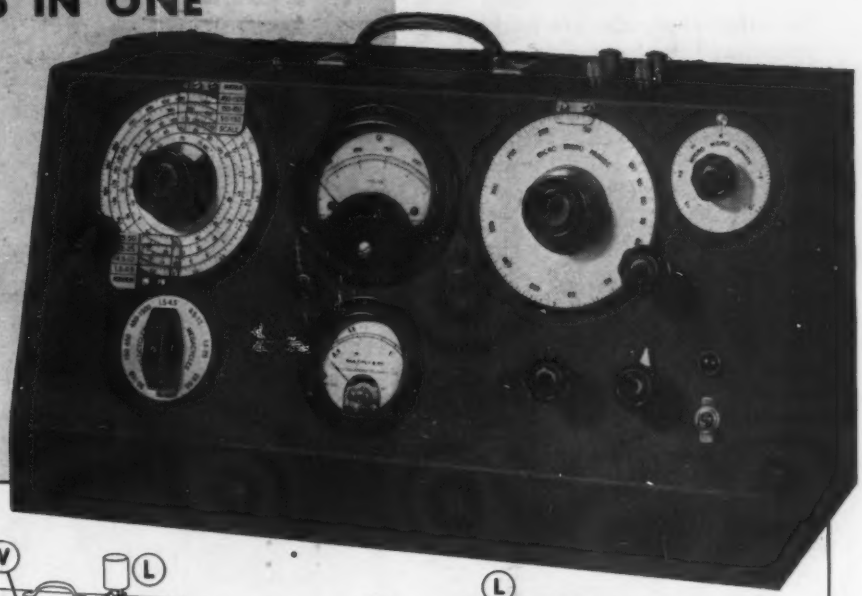

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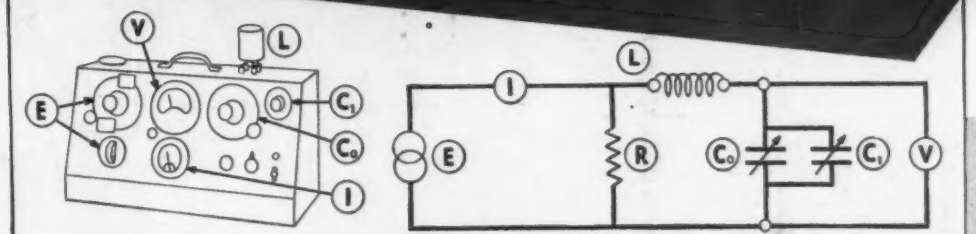

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Q and capacitance measurement of capacitors.
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SPECIFICATIONS

Oscillator Frequency Range: **50 kc. to 75 mc. in 8 ranges.**
Oscillator Frequency Accuracy: **± 1%, 50 kc. — 50 mc.**
± 3%, 50 mc. — 75 mc.

Q-Measurement Range: **Directly calibrated in Q, 20–250: "Multiply-Q-By" Meter (I) calibrated in tenths from x1 to x2, and also at x2.5; extending Q range to 625.**

Q-Measurement Accuracy: **Approximately 5% for direct reading measurement, for frequencies up to 30 mc. Accuracy less at higher frequencies.**

Capacitance Calibration Range: **Main capacitor section (C_o) 30–450 mmf accuracy 1% or 1 mmf whichever is greater. Vernier capacitor section (C_1) +3 mmf, zero, −3 mmf, calibrated in 0.1 mmf steps. Accuracy ± 0.1 mmf.**

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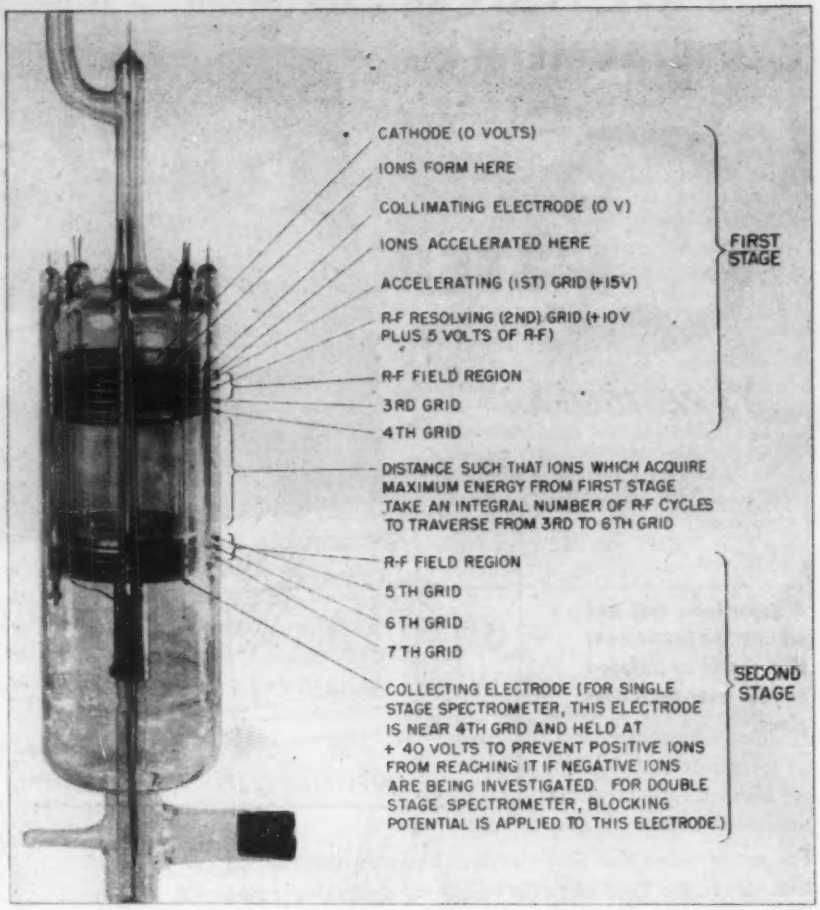
the other electrodes are held at appropriate direct potentials. As in the single stage unit, the ion current is measured at the plate. The exacting requirements of negative-ion separation require the use of a small magnetic field produced with external coils, but no magnetic field is required if positive ions are being separated.

Because large electromagnets or tubes containing electrodes with elaborate systems of slits are not required in the r-f mass spectrometer, this new instrument should find wide application where its resolution is sufficient. One of the principal limitations upon the resolution possible with ordinary mass spectrometers using magnetic deflection of beams is the spread in energies of the ions at the source. The percentage spread can be reduced by increasing the voltage applied to the ions before they are magnetically resolved, but the extent to which they can be accelerated is limited by the magnetic field strength that can be produced within the tube.

In the r-f mass spectrometer, this difficulty is eliminated so that the voltage applied to the ions can be pushed easily to at least an additional order of magnitude. The frequencies that are required are then increased by an amount equal to the square root of the factor by which the voltage is increased. Increasing the voltage reduces the percentage spread of the measured mass line, which is due to the velocity spread in the ion source, by the same percentage that the accelerating voltage is increased.

The large number of grids (seven) in the double-stage spectrometer would be impractical if it were not that a knitted wire fabric, which has more than 95-percent open area and with which this type of tube can readily be constructed, is now available. The simplicity and low cost of the r-f mass spectrometer should make it attractive in those applications in which its special characteristics make it superior to other kinds of mass spectrometers. Although the full possibilities of the new tube have not yet been explored, preliminary experimentation with it suggests that it will have wide application.


CATHODE (0 VOLTS)
IONS FORM HERE
COLLIMATING ELECTRODE (0 V)
IONS ACCELERATED HERE
ACCELERATING (1ST) GRID (+15V)
R-F RESOLVING (2ND) GRID (+10V PLUS 5 VOLTS OF R-F)
R-F FIELD REGION
3RD GRID
4TH GRID
FIRST STAGE
DISTANCE SUCH THAT IONS WHICH ACQUIRE MAXIMUM ENERGY FROM FIRST STAGE TAKE AN INTEGRAL NUMBER OF R-F CYCLES TO TRAVERSE FROM 3RD TO 6TH GRID
R-F FIELD REGION
5TH GRID
6TH GRID
7TH GRID
COLLECTING ELECTRODE (FOR SINGLE STAGE SPECTROMETER, THIS ELECTRODE IS NEAR 4TH GRID AND HELD AT + 40 VOLTS TO PREVENT POSITIVE IONS FROM REACHING IT IF NEGATIVE IONS ARE BEING INVESTIGATED. FOR DOUBLE STAGE SPECTROMETER, BLOCKING POTENTIAL IS APPLIED TO THIS ELECTRODE.)
SECOND STAGE

Radio-frequency fields in two-stage mass spectrometer separate ions by passing only those whose initial mass and velocity give them a transit time comparable to r-f period

Noise in Vacuum Phototubes at High Current Levels

By R. F. Morrison

National Bureau of Standards
Washington, D. C.

Measurements of the output noise from phototubes were made and compared to the theoretical noise due solely to shot effect. The good agreement between measured and computed values indicates that, at cathode currents from as low as 50 microamperes to as high as 1.0 milliampere, shot effect is the only important source of noise.

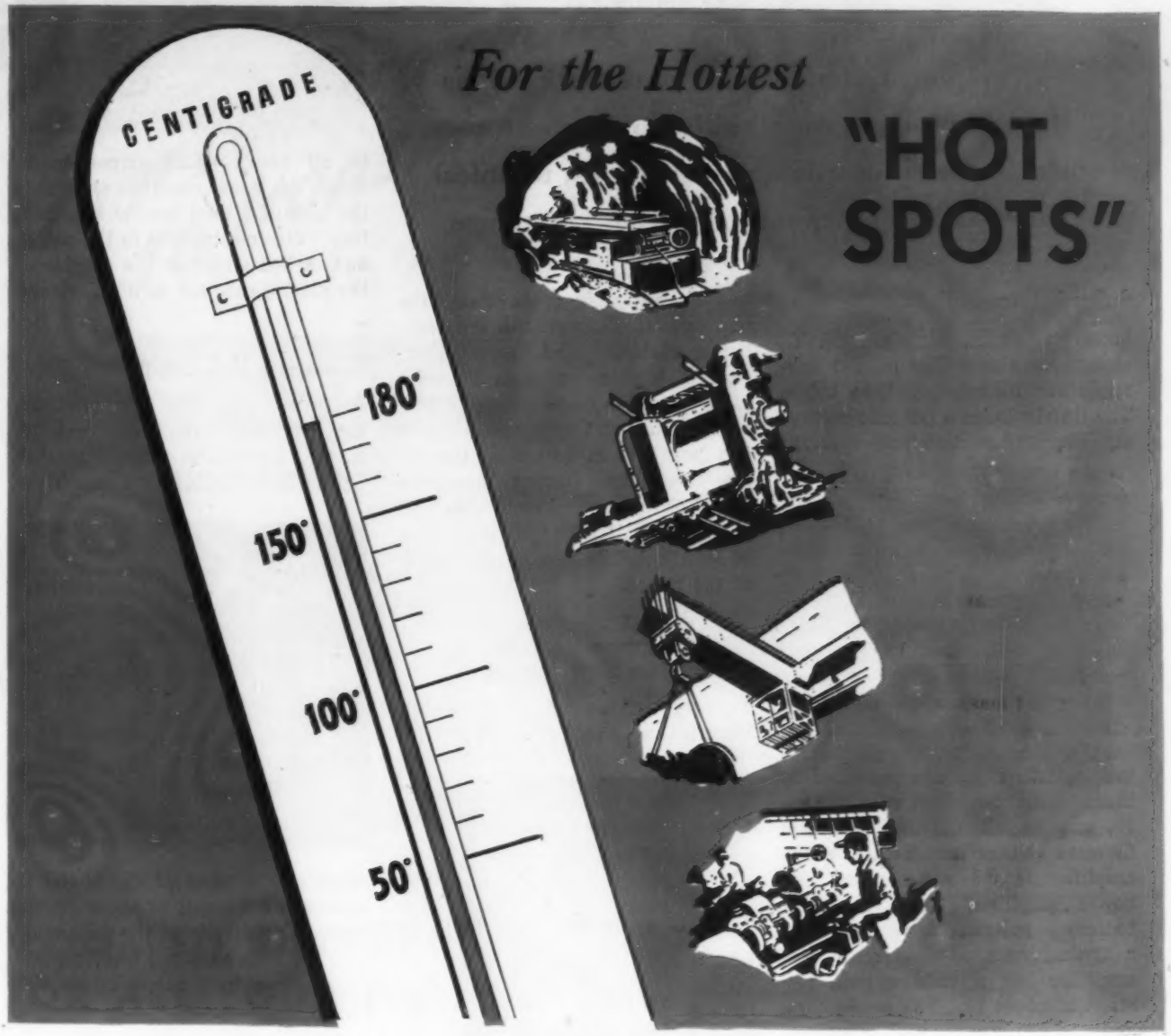
Sources of Noise

The flow of electrons from cathode to anode of a phototube under steady illumination is not perfectly uniform. Although the average current is constant, there are small fluctuations due to the random nature of photoelectric emission. These fluctuations produce noise that limits the percent modulation which may be used in optical systems having phototube detectors. Knowledge of the amount of noise generated in phototubes is essential to the design of precision optical equipment. Several investigators have measured shot effect noise at low frequencies, approximately 1,000 cps, with phototube currents of the order of a microampere or less[1,2].

The mean relative fluctuation δ in number of emitted electrons can be deduced from the theory of

(continued on p 162)

A MAGNET WIRE



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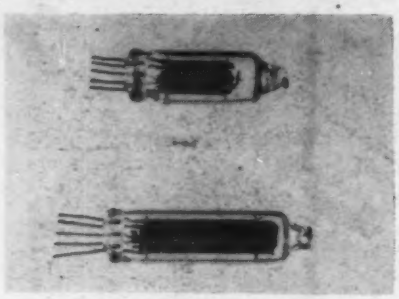
NEW PRODUCTS

Edited by A. A. McKENZIE

New equipment, components, tubes, testing apparatus and products closely allied to the electronics field. A review of catalogs, handbooks, technical bulletins and other manufacturers' literature

Subminiature Tubes

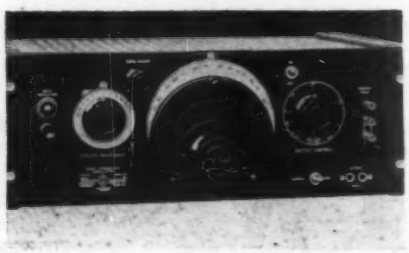
SONOTONE CORP., Elmsford, N. Y., announces a new line of T-2 subminiature filamentary type tubes. The line includes a pentode voltage amplifier and pentode power-output



tube. Both types are produced in three filament current ratings: 20, 15, and 10 milliamperes. Normal filament voltage across the voltage amplifier is 0.6 volt; across the power amplifier, 1.2 volt. With battery supplies of about 20 v and a typical hearing-aid circuit, the amplifier has a voltage gain per stage of about 75. The power tube delivers 2 milliwatts with a battery drain of 10 milliwatts.

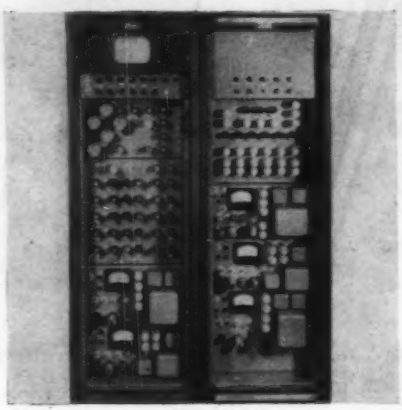
Beat-Frequency Oscillator

GENERAL RADIO Co., 275 Massachusetts Ave., Cambridge 39, Mass. Type 1304-A beat-frequency oscillator supersedes the older type 913-C. Although it is identical in overall size and frequency range the new oscillator has greater accuracy, better stability, and lower distortion. Frequency range is 20 cycles to 20 kc with accuracy of ± (1 percent + 0.5 cycle) after the dial zero has been set in terms of the a-c line frequency. Output impedance is 600 ohms; normal maximum output is 0.3 watt with total distortion of less than 0.25 percent over most of the range.



Television Equipment

TELEQUIP RADIO Co., 1901 South Washtenaw Ave., Chicago 8, Ill.



The television picture generator illustrated is representative of a line of equipment for studio rehearsal or broadcast use. The TMG-100A monoscope picture generator and distribution panel are also available.

Subminiature Battery

NATIONAL CARBON Co., 30 East 42nd St., New York 17, N. Y. A new hearing aid A battery with life

of 80 hours (4.25 ampere-hours under ASA test conditions) is only the size of a dual penlite-type battery. Zinc electrode is in the center and carbon strips on the outside of the plastic case act as depolarizers.

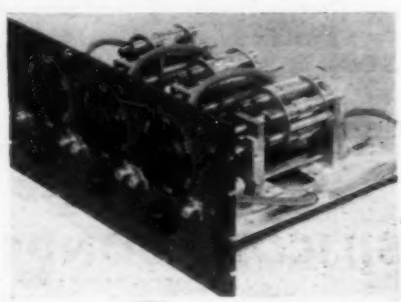
Sensitive D-C Scope

AMERICAN BRITISH TECHNOLOGY, Inc., 57 Park Ave., New York 16, N. Y., distributors for Furzehill Labs. Model 1684K is a new high-

sensitivity version of the Model D scope and has a gain of about 10,000 times. Sensitivity of the d-c amplifiers for both axes is 1 millivolt per inch. Frequency range up to 300 kc.

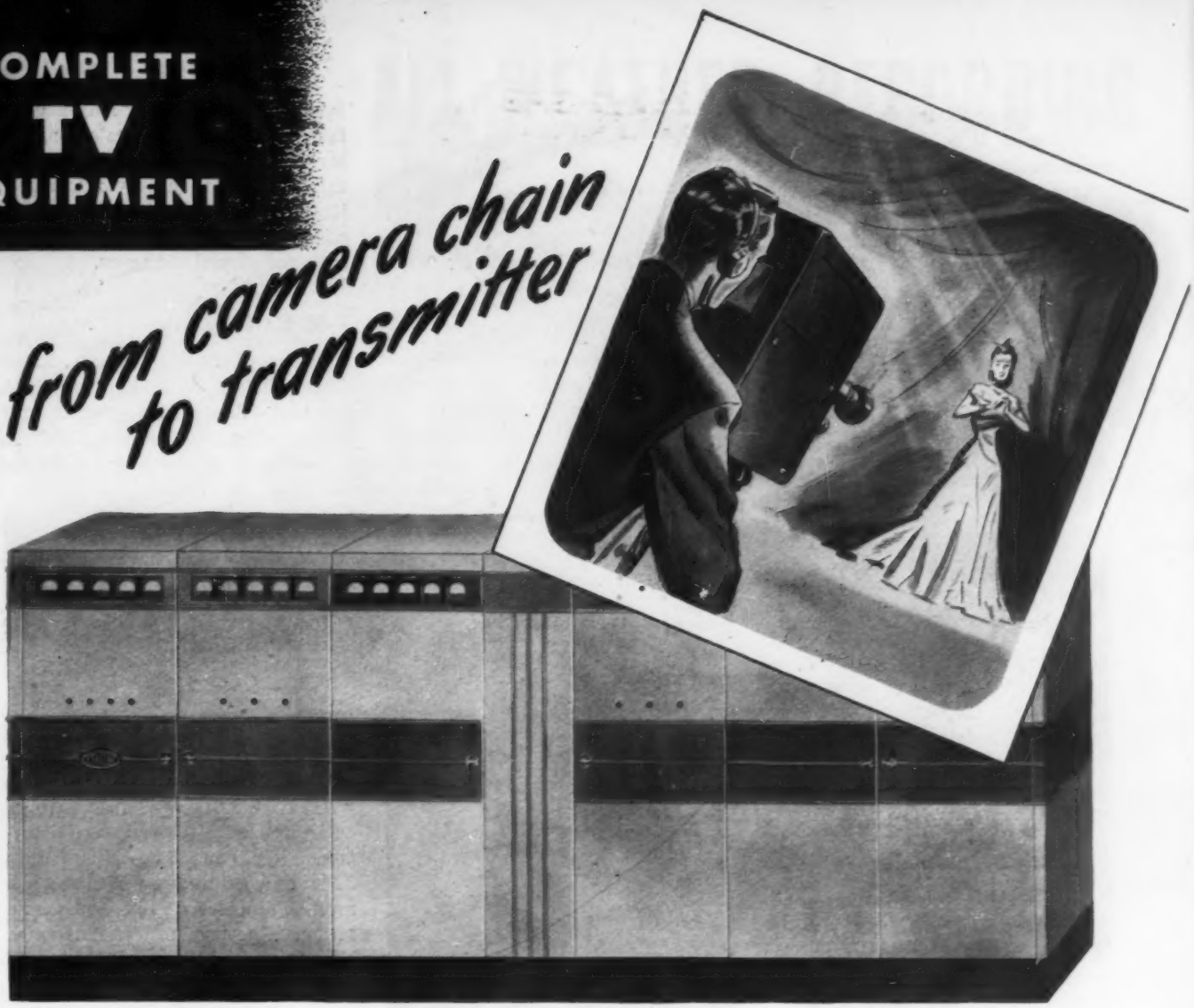
Step Attenuator

WEINSCHEL ENGINEERING Co., 123 William St., New York 7, N. Y. A new step attenuator can be used in the frequency range from 0 to 1,000 mc, or by heterodyne methods its



COMPLETE
TV
EQUIPMENT

from camera chain to transmitter



LOOK TO RAYTHEON FOR *ALL* YOUR NEEDS

RAYTHEON is prepared to furnish complete equipment for television stations. Through this one dependable and reliable source of supply you can obtain any single item or an entire installation ranging from camera chains to antenna and associated equipment . . . including 50 watt microwave equipment for remote pickup, STL, or point-to-point relay. Raytheon stands ready to provide you with prompt and intelligent service at all times.

RAYTHEON

NEW ENGLAND
Albert Keleher, Jr.
Raytheon Manufacturing Co.
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WA. 5-5860, Ex. 422

CHATTANOOGA, TENNESSEE
W. B. Taylor
Signal Mountain
8-2487

CHICAGO 6, ILLINOIS
Warren Cozzens
Ben Farmer
222 West Adams Street
Ran. 7457

DALLAS 8, TEXAS
Howard D. Crissey
414 East 10th Street
Yale 2-1904

NEW YORK 17, NEW YORK
Henry J. Geist
60 East 42nd Street
MU. 7-1550

SAN FRANCISCO, California
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49 California Street
Sutter 1-0475

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Adrian VanSanten
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Excellence in Electronics

RAYTHEON MANUFACTURING COMPANY

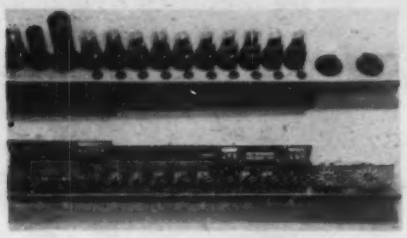
Industrial and Commercial Electronic Equipment,
FM, AM and TV Broadcast Equipment, Tubes and Accessories

WALTHAM 54, MASSACHUSETTS

range can be effectively extended to 3,000 mc. It is useful for impedance measurements, taking antenna characteristics, calibrating voltmeters, and checking receiver gain. Attenuation is 0 to 60 db.

Electronic Counters

TECHNITROL ENGINEERING CO., INC., 3212 Market St., Philadelphia 4, Pa. The basic decade electronic



counter illustrated is combined with switching circuits for counting and timing circuits that involve speeds exceeding 150,000 counts per second. Predetermined counting, measurement of elapsed time to less than 7 microseconds, and various other features are included.

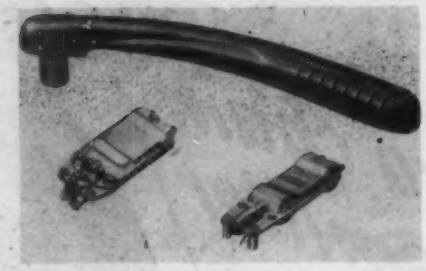
Loudspeaker

KLIPSCH AND ASSOCIATES, Hope, Arkansas. The new Style 5 high-fidelity loudspeaker is complete

with cabinet. Each loudspeaker comprises a high-frequency tweeter and new K-3-C woofer with response down to nearly 35 cycles. Equipment is distributed through Brociner Electronics Lab., 1546 Second Ave., New York 28, N. Y.

Tone Arm

WEBSTER ELECTRIC CO., Racine, Wisconsin, has announced the



Featheride tone arm and two new crystal cartridges for reproduction of long-p'aying microgroove records. The unit is balanced to maintain 7-gram tracking pressure. Model F12 cartridge is for long-playing records only, and model F11 plays either microgroove or standard records.

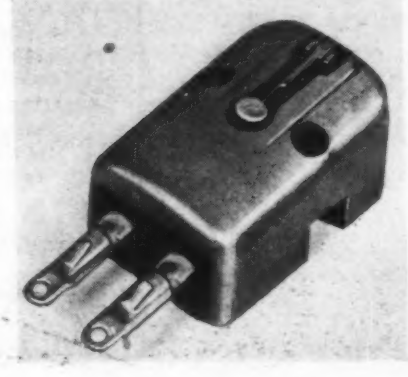
Television Test Device

RADIO CORP. OF AMERICA, Camden, N. J. Type WA-21A video sweep generator, when used with suitable

detector and oscilloscope, facilitates rapid testing of television i-f frequency systems with visual observation of the frequency response characteristic through a range of 100 kc to 10 mc.

Microgroove Cartridge

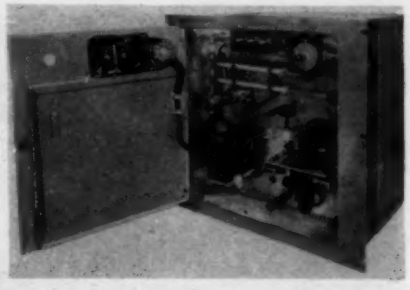
GENERAL ELECTRIC CO., Syracuse, N. Y. A new variable reluctance



cartridge designed for long-playing microgroove records has a sapphire stylus, 1 mil in diameter. One-third smaller than previous models, its shape makes it adaptable to various tone arms and gives more clearance for record changers.

F-M Radio Link

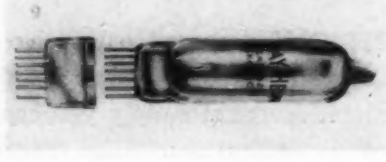
FEDERAL TELEPHONE AND RADIO CORP., Clifton, N. J. The FTL-11-A is a high-fidelity studio-to-transmitter radio link for f-m broadcasting. It operates in the 940 to 952-mc



band and permits program transmission up to line-of-sight ranges of approximately 30 miles. Distortion is less than 0.5 percent between 50 and 15,000 cycles, with the noise level 65 db below 100-percent modulation. The transmitter illustrated here has a power output of about 3 watts.

Subminiature 6AK5

RAYTHEON MFG. CO., Newton, Mass. The new subminiature type CK-5702/CK605CX tube is now avail-



able. Aside from a small difference in heater current, the tube is electrically interchangeable with the type 6AK5. Sockets for the new tube are also available.

Tuned-Ribbon Reproducers

AUDAK CO., 500 Fifth Ave., New York 18, N. Y. The LM series of Tuned-Ribbon reproducers was designed for use with long-playing records. They operate with a point

(Continued on p 182)

FOR FINER ALL-WEATHER RECORDING

Now audiodisc* *lacquer provides permanent resistance to humidity*

Excessive humidity has long been one of the industry's major problems—both to the manufacturer and to the recordist. Humid conditions in factories have frequently held up production and caused excessive spoilage. Also, discs which have absorbed too much moisture make poor recordings. The noise level increases progressively while recording and the cut gets greyer and greyer.

Air conditioning has been tried by several producers, but this does not prevent moisture absorption during transportation and storage. The real solution lies in the formulation of a lacquer which will provide permanent resistance to humidity. This has now been successfully accomplished by our research laboratory. Here are the facts:

1. The Improved Audiodisc Formulation has eliminated all production difficulties due to excessive humidity. During the past summer no trouble was encountered, even with humidity as high as 90%.

2. Countless Tests in our "weather room" have proved the new Audiodiscs to be remarkably resistant to moisture absorption. Discs subjected to a temperature of 90° at 80% to 90% humidity for many weeks show no increase in noise level while recording. Ordinary discs, under the same conditions, show a noise level increase of from 15 to 25 db. The most conclusive proof of all, however, has come from the field—for during the past summer, one of the most humid on record, our customers have reported no difficulties in recording or reproduction due to humid conditions.

3. This "Weather-Proof" Feature has been achieved without any basic change in our lacquer formulation. Recordists will therefore continue to note the outstanding qualities in recording, playback and processing which have made for Audiodisc leadership.

•

This improved humidity-resistant lacquer is now used on all Audiodiscs. It is your assurance of finer, all-weather recording—with the same consistent, uniform quality which has characterized Audiodiscs for a decade.

*Reg. U. S. Pat. Off.

Audiodiscs are manufactured in the U.S.A. under exclusive license from PYRAL, S.A.R.L., Paris.

Audio Devices, Inc., 444 Madison Ave., N.Y.C.

Export Dept: Rocke International, 13 East 40th Street, New York 16, N. Y.

they speak for themselves audiodiscs

NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

Radio Parts Show; IRE fellowships announced; midwest television networks; National Electronics Conference program

Television Application Freeze Announced by FCC

RECENT ACTION by the FCC temporarily halted any further authorization of new television stations. Chairman Wayne Coy announced that the freeze would remain in effect long enough for the Commission to decide whether certain changes should be made in engineering standards for the avoidance of interference between television stations in adjacent cities. This investigation would probably take about six months.

The freeze order applies only to stations for which applications are pending. Stations previously authorized, including the thirty-seven now on the air and the eighty-six now under construction, are not affected.

Coolidge Lab Dedicated

GROWING DEMAND for specialized industrial and medical applications for x-ray led to the foundation of the world's largest x-ray development laboratory, by General Electric X-Ray Corp. at Milwaukee, Wisconsin. The $750,000 research center will be known as Coolidge Laboratory, in honor of William D. Coolidge, x-ray pioneer and director emeritus of the GE Research Lab, Schenectady, N. Y. Dedication ceremonies, attended by 200 radiologists, 1,100 employees, and 200 industrial leaders, physicists and research scientists, were highlighted by the addresses of Charles E. Wilson, president of General Electric, and Dr. William D. Coolidge, the guest of honor.

Since GE's expansion program began a year ago, seven major pieces of equipment have been developed by the Coolidge Laboratory: the Cardioscribe, a new direct-writing electrocardiograph that eliminates developing a film to read the heart's action; a direct-recording x-ray diffraction machine, which opens broad fields for the application of diffraction and facilitates analysis of unknown materials; the Maximar 100, a 100,000-volt machine designed especially for treating skin diseases; the Maxiscope 500, a new type of robot x-ray apparatus equipped for high-voltage radiography to provide better x-rays of heavy body sections; a new type Inductotherm, not yet ready for announcement; a special fluoroscope used by shoe manufacturers to find unwanted nails in shoes; and a new line of x-ray film illuminators using circular fluorescent lamps.

William D. Coolidge, father of modern x-ray tube, examines a million-volt x-ray tube

New IRE Section

OVER FORTY PEOPLE attended a recent organizational meeting of the IRE, held in Omaha, Nebraska, and signed a petition asking the national board of directors of IRE to form an Omaha-Lincoln Section. Papers were read, a collection was taken up to help finance the activity, and temporary officers were elected.

The meeting was presided over by George Hixenbaugh, chairman of the Cedar Rapids Section. An address outlining the place of the IRE in the local situation was given by T. A. Hunter, regional director. John A. Green, secretary-treasurer of Region 5, assisted with the organizational activity for the new section.

Rochester Fall Meeting

TENTATIVE PROGRAM of the Rochester Fall Meeting of members of the IRE and RMA Engineering Department, to be held at the Sheraton

UHF EQUIPMENT

DEVELOPED • DESIGNED • PRODUCED

1. **DEVELOPMENT** .. from concept of idea to working model
2. **DESIGN** ..... by thoroughly experienced UHF engineers
3. **MANUFACTURE** .. using methods especially suited to UHF work

Specialized UHF knowledge, experience and shop practice enable Lavoie Laboratories to handle every phase of electronic production efficiently and economically.

Precision work and low unit cost are based on these factors developed through years of practical specialization in this field.

• • • LAVOIE PRODUCTS: Frequency Meters — Frequency Standards — Receivers — Transmitters — Antennas and Mounts.

Detailed information and estimates of LAVOIE service are available promptly without cost or obligation.

U H F

Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS
MORGANVILLE, N. J.

Specialists in the Development and Manufacture of UHF Equipment

Hotel, Rochester, N. Y., November 8, 9 and 10, 1948, is as follows:

Monday, Nov. 8

9:30 A. M.—Technical Session—B. E. Shackelford presiding:

A Television Station Selector Using Die Stamped Inductances, by A. D. Sobel of A. W. Franklin Mfg. Corp.

A discussion of Image Sharpness in Photography and Television, by O. H. Schade of RCA.

Application of Subminiature Tubes, by R. K. McClintock of Sylvania.

2:00 P. M.—Technical Session—D. B. Smith presiding:

The Transitrol, an Experimental AFC Tube, by J. Kurshan of RCA Laboratories.

A New Low-Noise, Low-Microphonic Miniature Tube, by C. R. Knight and A. P. Haase of GE.

4:00 P. M.—Committee Meetings

8:15 P. M.—General Session—E. F. Carter presiding:

What's When in America, by Kenneth W. Jarvis, consulting engineer.

9:15 P. M.—Stag Party, courtesy of American Lava Corp.

Tuesday, Nov. 9

9:00 A. M.—Technical Session—S. L. Bailey, presiding:

Report of RMA Safety Committee, by William Vassar of Emerson.

Developments in Germanium Crystals, by Stuart T. Martin and Harold Heins of Sylvania.

A Television Distribution System for Laboratory Use, by Joseph Fisher of Philco.

2:00 P. M.—Technical Session—D. D. Israel presiding:

A Direct-Coupled Video and AGC System for Television Receivers, by H. R. Shaw of Colonial Radio Corp.

A Pulse-Cross Generator for Television Receiver Production, by R. P. Burr of Hazeltine.

4:00 P. M.—Committee Meetings

6:30 P. M.—Stag Banquet—B. DeForest Bayly, toastmaster

Wednesday, Nov. 10

9:30 A. M.—Technical Session—O. L. Angevine, Jr. presiding:

Lightweight Pickup Design for Microgroove Record Playing, by B. P. Hafner, Elmo Voegtlin, C. D. O'Neill and R. S. Cranmer of Philco.

Symposium—What Constitutes High Fidelity, by Harvey P. Fletcher of Bell Telephone Laboratories, John K. Hilliard of Altec Lansing Corp. and C. J. LeBel, consultant.

High-Quality Audio System for Radio Receivers, by R. S. Anderson and B. E. Atwood of Stromberg-Carlson Co.

2:00 P. M.—Technical Session—K. J. Gardner presiding:

Front Ends of Television Receivers, by J. O. Silvey of GE.

A Picture-And-Sound-Modulated Generator for Television Receiver Production, by W. R. Stone of Hazeltine.

4:00 P. M.—Committee Meetings

8:00 P. M.—Photographic Session—A. L. Schoen presiding.

Audio Engineers Compare Loudspeakers

A RECENT MEETING of the San Francisco Section of Audio Engineering Society featured a listening test of twenty different commercial loudspeakers and a demonstration of a new tweeter-tweeter speaker. Groups of high-fidelity speakers were cross-compared, driven from the output of a pair of push-pull 211's operating essentially as a zero-impedance source. Audio was derived from an Ampex tape recorder.

The session concluded with a description and demonstration of a new h-f speaker developed by Bob Smith and Water Selsted, San Francisco audio engineers. The new speaker serves the range from 5,000 to 20,000 cps, operating above an ordinary tweeter, and is essentially nondirectional in both horizontal and vertical planes. It features a moving system of only 142 milligrams.

MEETINGS

OCT. 25–29: 64th semiannual convention, Society of Motion Picture Engineers, Hotel Statler, Washington, D. C.

OCT. 27–28: Annual Convention, Society for Non-Destructive Testing, Hotel Adelphia, Philadelphia.

Nov. 4–6: National Electronics Conference, Edgewater Beach Hotel, Chicago.

Nov. 8–10: Twentieth Rochester Fall Meeting of members of IRE and RMA Engineering Dept., Sheraton Hotel, Rochester, N. Y.

Nov. 29–DEC. 1: Conference on electronic instrumentation in nucleonics and medicine, sponsored by IRE and AIEE, Engineering Societies Building, New York City.

Nov. 29–DEC. 4: 18th National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York.

DEC. 10–11: Southwestern IRE Conference, Baker Hotel, Dallas, Texas.

JAN. 10-12: Symposium on high-frequency measurements, held by Instruments and Measurements Committee jointly with the IRE and National Bureau of Standards, at Washington, D. C.

APRIL 11–15: Sixth Western Metal Congress and Exposition, Shrine Auditorium, Los Angeles, Calif.

MAY 16–20: Radio Parts Industry Trade Show and RMA Silver Anniversary Convention, Hotel Stevens, Chicago.

Navy Training by Television

EVALUATION and test of television as a vehicle for mass training of military personnel with a minimum of instructors is now under way at the Navy's Special Devices Center near Port Washington, Long Island. Weekly television lectures on naval science subjects are being telecast eight miles to classrooms at the Merchant Marine Academy, Kings Point, N. Y., where one-fifth of the third-year class will be taught two subjects by television. Other students will receive standard instruction, and results will be evaluated by the Psychology Department of Fordham University.

Plans call for a tryout of network television training before the end of the year, with lectures going out from Special Devices Center over existing and new coaxial lines and microwave relay facilities to Naval Air Reserve Stations at Squantum, Floyd Bennett, Willow Grove and Anacostia. In all these tests, tele-

(continued on p 212)

Newly-elected officers of the San Francisco Section of Audio Engineering Society are, left to right: Myron Stolaroff, Ampex Electric Corp.; Jack Mullen, Bing Crosby Enterprises; Harold Lindsay and Frank Lennart, Ampex; Don E. Lincoln, Audiophone; I. R. Ganic, Audiophone (chairman); Walter T. Selsted, Pacific Broadcasting; Dick Beck, C. C. Brown and Ross H. Snyder, KJBS-FM

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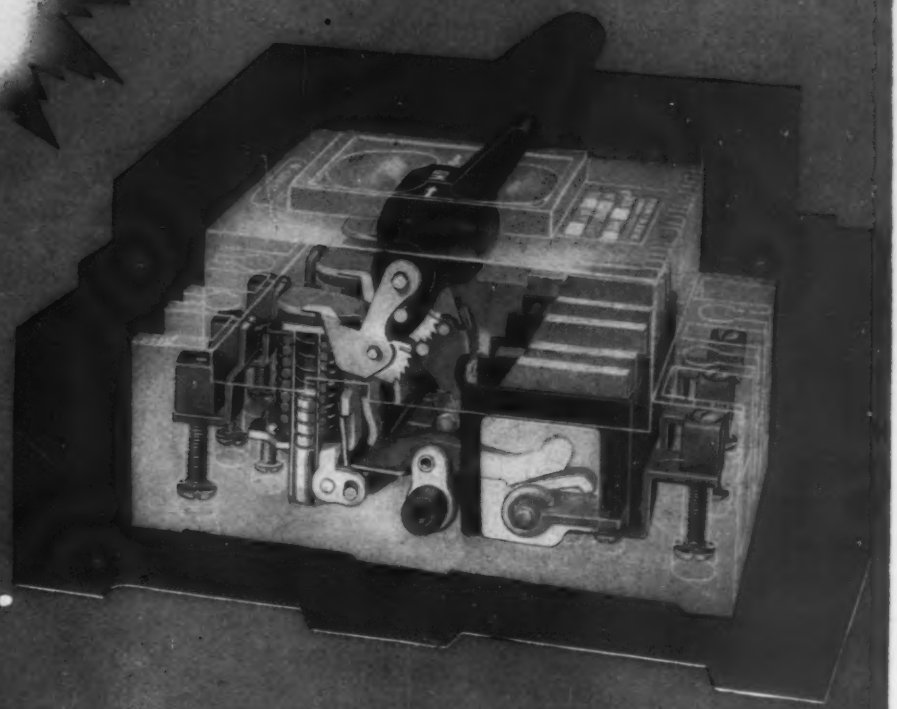
HEINEMANN

MAGNETIC CIRCUIT BREAKERS

are

fully
electro magnetic



Therefore they carry up to full rated current under all conditions.

They are manufactured with instantaneous trip or time delay.

Because they are entirely electro-magnetic in action and do not depend on any thermal unit, HEINEMANN CIRCUIT BREAKERS will not trip before the current reaches the trip point specified. Whatever the surrounding temperature, the breaker will trip only on a load in excess of its rating.

EST. HECO 1888

HEINEMANN ELECTRIC COMPANY

97 PLUM ST. TRENTON, NEW JERSEY

A lot of speaker in a little space

Western Electric 755A

TRY listening to the 755A *first* . . . *then* look at its size! You'll be amazed that so much *performance* can be packed into so little *space.*

Covering the frequency range from 70 to 13,000 cycles, the 755A gives brilliant tonal quality, faithful reproduction. Its 8-watt continuous capacity is ample for the general run of applications. And you get all this in a speaker only 8⅜" in diameter—only 4¾ pounds in weight!

Use the 755A in broadcast stations, wired music, program and sound distribution systems, home radios and record players.

You can get 755A's from stock in quantity. Call your nearest Graybar Representative—or write to Graybar Electric Co., 420 Lexington Ave., New York 17, N. Y.

—QUALITY COUNTS—

Distributed by GraybaR
OFFICES IN 100 PRINCIPAL CITIES

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TUBES AT WORK
(continued from p 122)

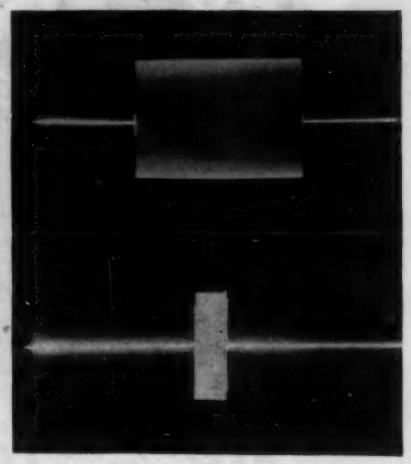

FIG. 4—Long exposure oscillograms showing signal pulse and gated response

parameters may be adjusted independently.

This circuit is sufficiently stable for close comparison of amplitudes, wave shapes and phase angles. Oscillator frequency drift is small enough to permit accurate measurements extending over 15 minutes or more. Operation of the receiver gate can be adjusted within a few microseconds. Figure 4 illustrates the quality of the transmitted wave packet and the gated receiver signal.

This work was supported in part by the Navy Department, Bureau of Ships, under Contract NObs-25391, Task No. 1.

REFERENCES

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Electronic Fuse

OCCASIONALLY situations arise in which it may be necessary to fuse a circuit when the current passing through the fuse does not exceed the normal current. A circuit which provides heat control by turning off and on a heating element may provide just such a situation. In case of failure of the control mechanism or of the contactor which opens and closes the

FOR RF HEATING—
BETTER PERFORMANCE
LONGER LIFE

ML-5668

(REPLACES TYPE 892 FOR ELECTRONIC HEATING)

*AND UNIQUE MACHLETT AUTOMATIC SEAL WATER JACKET**

ML-5668—Water-cooled RF Heating Triode. With Machlett Automatic Seal Water Jacket is directly interchangeable with Type 892. Max. Input—28 kw. Max. Plate Dissipation—20 kw. For equivalent anode dissipation *requires less than ½ water flow needed by the 892.*

*Pat. applied for

MACHLETT AUTOMATIC SEAL WATER JACKET.* No tools needed to open and close this new jacket. No worry about tube breakage or water leakage. Jacket cannot be opened unless water pressure is off, nor closed unless tube is properly seated. Your hand opens and closes a perfectly safe seal with just a single twist.

THE new Machlett ML-5668 is of special and direct interest to every operator of electronic heating equipment using the 892 type of tube. The ML-5668, in combination with the Machlett Automatic Seal Water Jacket, is directly interchangeable with the 892 and its jacket, and, since it is designed specifically for this type of service, will provide greater effectiveness and increased economy on both induction and dielectric heating applications. RF heating requires the very best in tube design, construction, and processing, and the ML-5668, with its extra-heavy and uniquely-processed anode, its mechanically-sturdier grid, cathode and terminal construction, truly meets the need. This tube, and those who use it, benefit fully from Machlett's advanced techniques of design and manufacture.

For better, more consistent performance—for lower operating costs—for longer tube life—replace the 892 with the ML-5668.

* * *

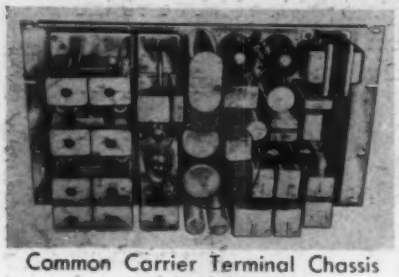
The advantages offered by ML-5668 are also available to manufacturers and users of equipment employing other communication-type tubes, such as the 889A and 880, through the *new* Machlett Types ML-5604, ML-5619, ML-5666 and ML-5658. These RF heating tubes were designed, built and rated for electronic heating service, without compromise with the needs of other applications. For the complete story of the improved performance and lower costs offered by these tubes, write Machlett Laboratories, Inc., Springdale, Connecticut.

MACHLETT

Over 50 Years
of Electron Tube Experience

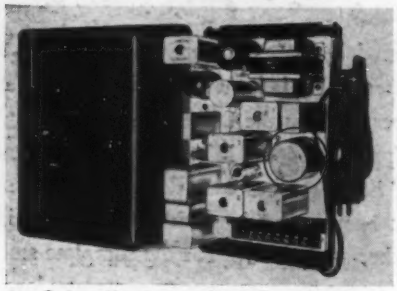
MACHLETT LABORATORIES, INC.
Springdale, Connecticut

Sigma RELAYS
ARE USED IN
Western Electric
POWER LINE
CARRIER TELEPHONE SYSTEM



Common Carrier Terminal Chassis

Subscriber Coupling Unit



Subscriber Terminal Equipment

The Western Electric M1 Power Line Carrier Telephone System permits telephone service in thousands of farm houses having electric power service but no telephone wire line connections. It will help raise living standards in many rural areas.

Sigma Relays are used for three functions in this equipment, two of which are unusually exacting. By careful cooperative study of each application Sigma was able to work out solutions using highly refined but none the less conventional sensitive relays of standard Sigma design — available at comparatively low cost.

From vending machines to V-Bombs specialized relay design plus facility at solving problems involving circuit, relay and function enable Sigma to render valuable service.

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circuit, the heating element will continue to raise the temperature above that desired, and may constitute a fire hazard.

An ordinary fuse will not provide protection against this hazard, since the current in the heating element has not changed appreciably from its normal value. Temperature sensitive devices may be too expensive or may not be desirable for other reasons.

In one electric blanket, a feeler wire is placed through the blanket that responds to temperature change, and this response serves as the basis for a control voltage. The control opens or closes a contactor to maintain the proper heating in the blanket. If the contactor fails to open at the proper time, some means must be provided to open the circuit to prevent excessive overheating.

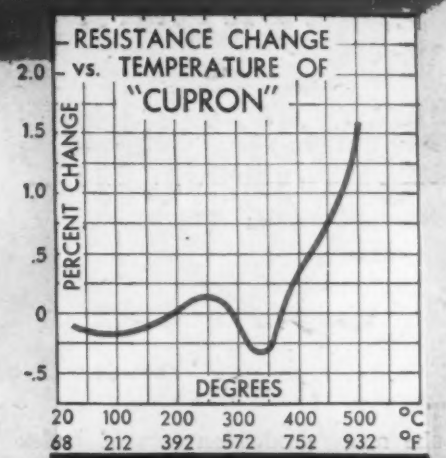
Both the desired protection and comfort are obtained with a thyratron. The current carried by the tube when it is conducting is limited by the impedance in series with the tube, which need not necessarily affect the operation of the circuit to be fused.

When two cathode connections are provided in a thyratron tube, one side of the voltage supply can be connected to one of the cathode connections, and the other cathode terminal connected to the circuit, thereby making a lead inside the tube actually a part of the supply line to the circuit. The anode of the thyratron is connected to the other side of the supply voltage, the tube normally not conducting current and therefore not affecting the operation of the circuit.

The grid circuit of the thyratron is connected to the control circuit in such a way that as a fault occurs which would cause overheating of the element, the negative grid voltage on the thyratron is reduced to a point where the tube conducts. The tube current will be far in excess of the circuit current and will be sufficient to burn out one of the cathode connections, thereby opening the supply line to the heating element. Like any other fuse, the tube is rendered useless and must be replaced when the circuit fault has been corrected.

The GL-1367, a General Electric

Photomicrographics are only part of the story...



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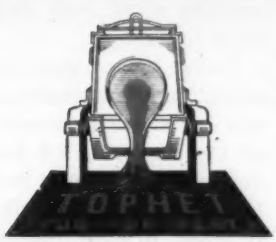

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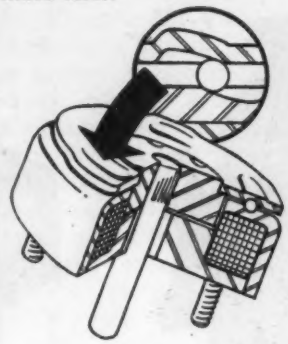

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MODEL No.	2	5	6	7	8
Diameter	1⅛"	1⅞"	2¼"	2¾"	3⅜"
Torque Lb.-Inches	¼	5	10	25	50
Weight Lbs.	⅛	½	1	2¼	4¼

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development, is designed specifically for such use. Two cathode connections are provided so that the series connection can be made in the circuit supply line, and the tube is designed to burn out this connection when the tube is operated directly across a 110-volt source. The cathode connections normally carry about 1.5 ampere.

Improving Performance of Milliwatt Relays

By Gene Halperin
Sands Point, N. Y.

Many relays of the sensitive polarized type operating on as little as one-half milliwatt have contact characteristics which make operation in aircraft or other mobile applications difficult. The causes for unsatisfactory operation are generally inherent in the physical design or a function of the high sensitivity of the relay.

Several milliwatt relays investigated for use in an airborne temperature control exhibited almost a linear relationship between input current to the coil and contact-arm motion. Where the input signal is a slowly varying function, such as in a temperature control, this linearity can cause the moving contact to hover a few ten-thousandths of an inch away from the fixed contact.

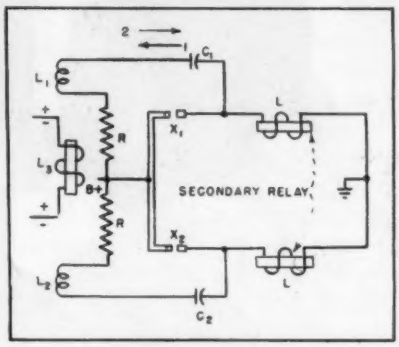

FIG. 1—Operation is improved by addition of coils L_1 and L_2

Under these conditions any small vibration or variation in line voltage can cause a momentary closure of the contacts, but since there is not yet enough input to develop contact pressure, the moving arm when relieved of the disturbing force (vibration or voltage variation)

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Below . . . A Clarostat
Wire-wound Potentiometer and Rheostat
Product shown thru courtesy of
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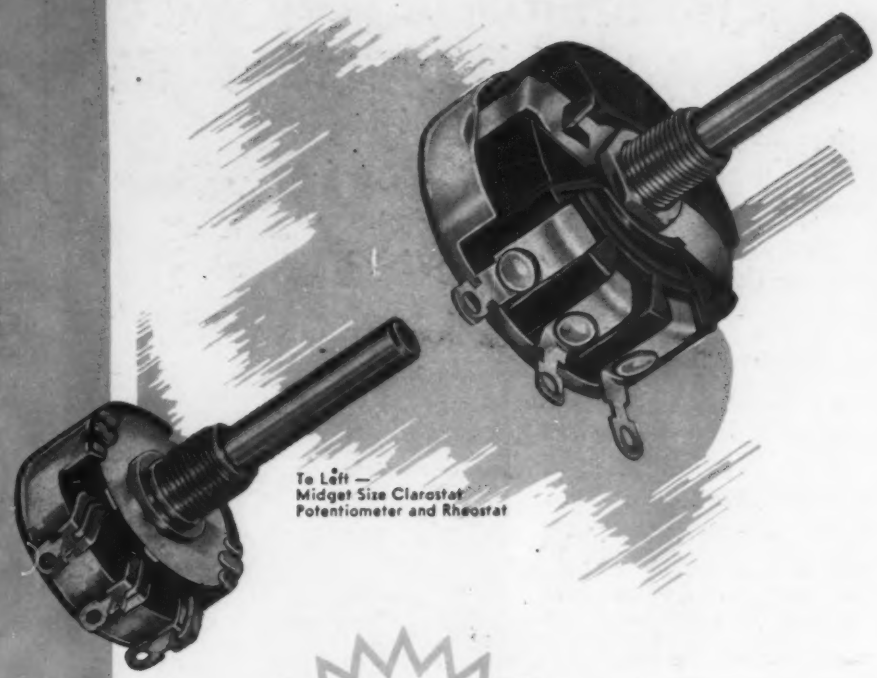

To Left —
Midget Size Clarostat
Potentiometer and Rheostat

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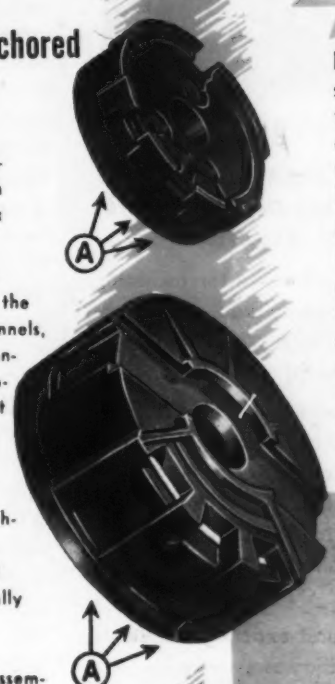
They indicate what proven molding techniques can accomplish in small space. Both bases shown actual size. Featured reference to letters "A" identify specially recessed channels for permanently positioning and accurately anchoring multiples of metal terminals . . . Final assemblies are pictured at top of page.



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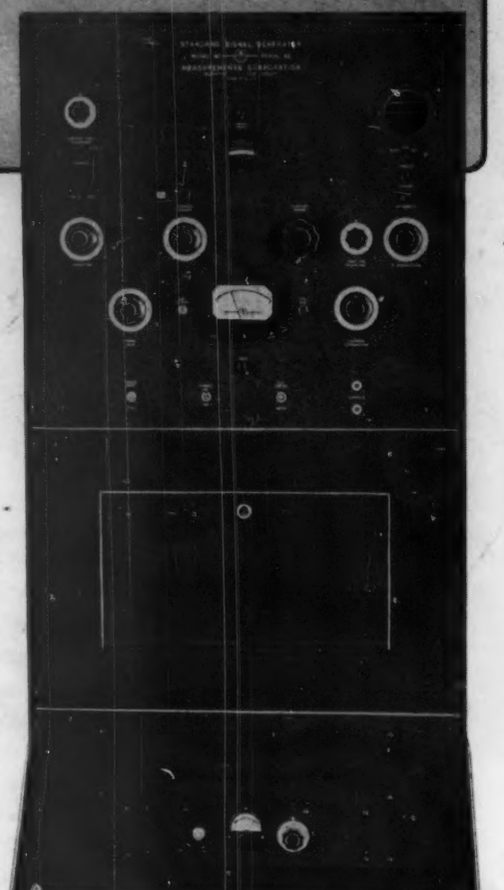
TELEVISION STANDARD SIGNAL GENERATOR

MODEL 90



SPECIFICATIONS:

● CARRIER FREQUENCY

RANGE: Continuously variable from 20 to 250 megacycles, in eight ranges.

ACCURACY: Crystal frequency standard permits setting to .01%. Dial scale may be set to 0.1%.

STABILITY: Warm-up drift less than .05%.

LEAKAGE: Less than 10 microvolts.

● MODULATION

Continuously variable from zero to 100%.

ENVELOPE: Sinusoidal, or composite television. Bandwidth to 3 db is 4 Mc. Rise time from 10% to 90% modulation 0.15 microsecond. Overshoot less than 5%. Slope less than 5% on 60 cycle square wave.

INPUT IMPEDANCE: 75 ohms ± 10% (RMA Standard).

INPUT LEVEL: 1.5 volts peak to peak minimum level for 100% modulation. Black negative polarity.

MODULATION PERCENTAGE: Zero to 110%; plate modulation.

● OUTPUT

LEVEL: Continuously variable from 0.3 microvolt to 0.1 volt balanced to ground (measured at 100% modulation level).

IMPEDANCE: (a) 107 ohms line to line (balanced).
(b) 53.5 ohms line to ground (unbalanced).
(c) Suitable pads may be employed to alter these impedances.

● DIMENSIONS

OVERALL: Height—58¾"; Width—28¼"; Depth—25½".

WEIGHT: Model 90—302 pounds. External Voltage Regulator 92 pounds.

POWER SUPPLY: 117 volts, 60 cycles.

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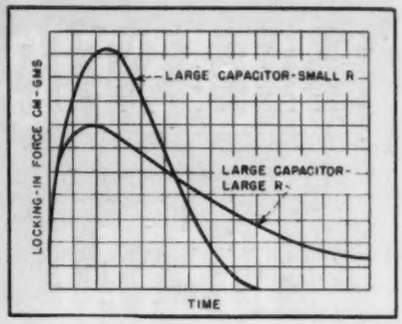

FIG. 2—Locking force as a function of *RC*

leaves the fixed contact drawing a small arc in the process. This arc maintains itself until the input is sufficiently high to develop contact pressure or until the arc causes welding of the contacts.

These arcs are of small, almost microscopic size and the welds would not be serious in a power relay. However, in sensitive relays, the arc generally passes enough current to cause chattering of the secondary relays with attendant intermittent operation of the control or indicating mechanism. In addition the welds cause shifts of the drop-out point. Some improvement may be effected by R-C suppressors used across the milliwatt relay contacts, but severe vibration will still cause unstable contact operation.

Figure 1 shows modifications made to a milliwatt relay, to make it more satisfactory for applications involving slowly changing quantities and severe vibration. The main winding of the sensitive relay is shown at L_3 connected to any source of d-c of reversible polarity, such as a resistance bridge.

Closing of Contacts

The movable armature carrying the two contacts X_1 and X_2 is connected to a source of voltage which operates the secondary relays when X_1 or X_2 make contact with their respective fixed surfaces. Coils L_1 and L_2 have been added to the relay and are located at the bottom of the coil form, underneath the main winding L_3. The turns ratio of auxiliary to main winding was chosen as 1 to 10, but can be made greater or less in accordance with the individual requirements of the application.

While contacts X_1 are open, capacitor C_1 is across the d-c line

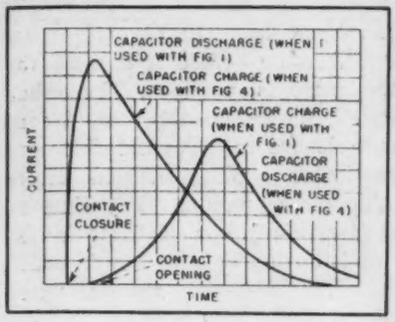
CAPACITOR DISCHARGE (WHEN USED WITH FIG. 1)
CAPACITOR CHARGE (WHEN USED WITH FIG. 4)
CAPACITOR CHARGE (WHEN USED WITH FIG. 1)
CAPACITOR DISCHARGE (WHEN USED WITH FIG. 4)
CONTACT CLOSURE
CONTACT OPENING
CURRENT
TIME

FIG. 3—Difference in charge and discharge action caused by secondary relay

through resistor R, auxiliary winding L_1 and the coil of the secondary relay L. It therefore assumes the potential of the voltage source. The first momentary contact between the surfaces of X_1 (even of a transient nature) allows the capacitor to initiate a discharge through the auxiliary winding L_1, resistor R and the closed contacts. The discharge has a current flow in the direction of arrow 1 and a magnitude fixed by the capacitance of C_1, the emf of the voltage source, resistance R and the d-c resistance of the auxiliary winding. If winding L_1 is phased so that current in the direction shown by arrow 1 generates ampere-turns additive to those of the main winding, a transient locking impulse is achieved. The armature is immediately subjected to an additional mechanical force due to the increased ampere-turns and locks in tightly to its fixed contact.

The magnitude of the locking impulse and its duration are determined by the magnetic circuit and the nature of the typical exponential discharge of the R-C combination. By suitable selection of the three variables the transient mechanical force on the armature can be adjusted through a wide range.

Figure 2 shows various methods of operation based on variations of R and C and the resultant variations in transient locking force. It also shows that, for any fixed number of turns in each auxiliary winding, it is possible to get a large locking impulse for a short time or a lesser locking impulse for a long time.

The choice of variable will be dictated by the specific application but the chosen parameters should allow the exponential locking impulse to

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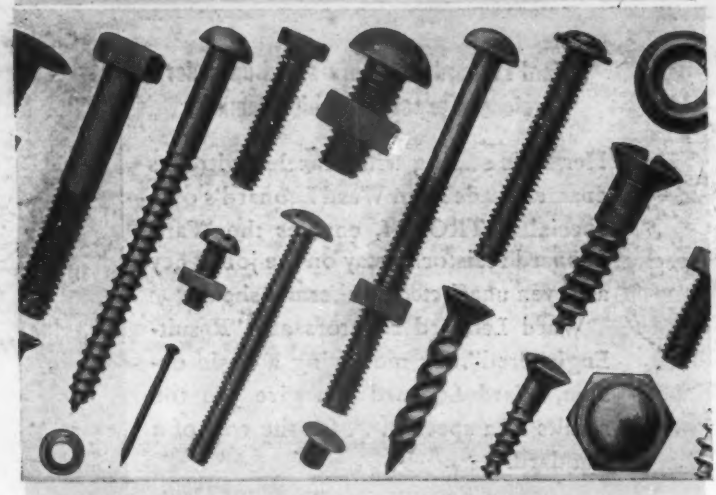

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fall to at least 10 percent of its initial value before it is time for the contacts to open. In other words, the shortest period of contact closure to be expected in any particular application will determine the maximum decay time of the transient impulse. This limitation is obviously necessary in order that the drop-out characteristics of the relay be unaffected by the presence of the additional transient ampere-turns.

Opening of Contacts

If the maximum decay time is made shorter than the smallest period of contact closure, the capacitor will always be in a substantially discharged condition by the time contacts X_1 break the circuit. Capacitor C_1, resistor R and winding L_1 will again be subjected to the supply voltage and a charging current will flow in the direction of arrow 2. Without mechanical switching, a reversal of current flow has been achieved in auxiliary winding L_1 and a negative or kick-out impulse will be applied to the armature.

The capacitor discharges exponentially on closure of X_1 but does not charge in the same manner because of the presence in the charging circuit of the highly inductive secondary relay coil. This action is illustrated in Fig. 3 where the discharge current rises almost as a step function (limited in rate of rise only by small inductances in the capacitor, wiring and coil L_1) and then falls exponentially to zero, while the charging current rises much more slowly to a maximum and then tapers off to zero.

Time Delay

A by-product of the circuit operation as described above is a finite amount of time delay in the opening of secondary relay L due to the charging current of capacitor C_1 which passes through the secondary relay coil L in the same direction as its normal closing current. This small delay in the opening of the secondary contacts is of considerable advantage in achieving stability in certain applications. Unfortunately, it is not always possible to achieve the desired amount of time delay when parameters are

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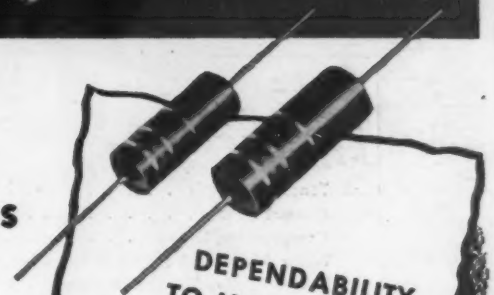

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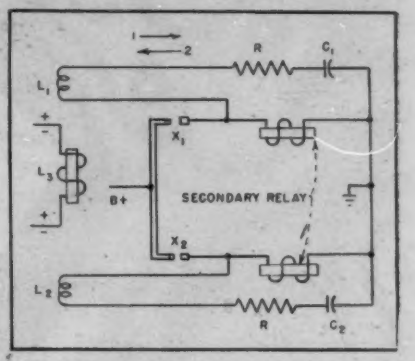

FIG. 4—Alternate circuit in which the charge and discharge actions are reversed from that of Fig. 1

chosen on the basis of locking and kick-out forces, but where such delay is beneficial and necessary, a compromise between locking force, duration and secondary time delay can usually be achieved.

The combination of R and C_1 constitutes a spark suppressor to reduce the arc across the contacts X_1 and X_2, in addition to its other functions.

Alternative Circuit

Figure 4 illustrates an arrangement which can be used in extreme cases of inadequate relay operation. It enables auxiliary winding L_1 to utilize to full advantage the discharge of C_1 without any attenuating effects from the opposite side of the circuit. The auxiliary winding circuits are connected across the secondary relay coils. The action of the transient network is now reversed from that shown in Fig. 1, since C_1 is discharged during the time that contacts X_1 are open and charges when they are closed, due to the line voltage which appears across the secondary relay coil.

The system operates as follows: When contacts X_1 close, the line voltage appears across the secondary relay coil. The rise of relay current lags due to inductance in the coil, but the voltage appears as a step-function. This causes a charging current to flow through winding L_1, capacitor C_1 and resistor R in the direction shown by arrow 1. The fact that the rise of current lags in the relay coil does not delay the charging of C_1 since the capacitor draws its charging power from the line. As the capacitor reaches line voltage, current 1 is reduced to zero and remains

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Dispatcher's office is in constant communication with vehicles at all times, directing them to the scene, checking on progress in bringing fire under control.

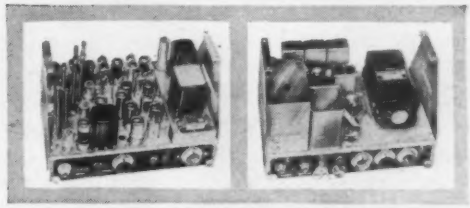

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Photo Courtesy Brown Geophysical

Special amplifier used in oilfield geophysical exploration and survey by Brown Geophysical Co. of Houston, Texas uses K connectors for the circuits on this Amplifier equipment.

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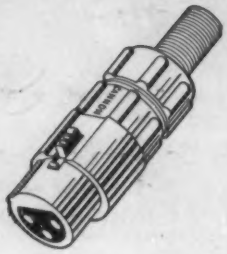
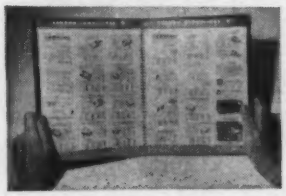


TYPE "XL" Series is two plugs and several receptacle types, with two insert variations of 3 and 4 contacts, 10 and 15-amp. Latchlock type connection.

TYPE "K" Series is made in several shell types, including the "RK", and approximately 190 insert arrangements among the 8 shell sizes for a wide variety of wire sizes, including coaxials.



For a survey of Cannon Plugs, write for the C-47 Condensed General Catalog, covering the 13 major type series and electrical specialties. . . Details on Type "K" are found in the K-945 Bulletin. Address Department K-120.

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zero until contacts X_1 open. The voltage across the relay coil decreases as its field collapses and the capacitor discharges with current flow 2.

The discharge current is in the same direction as the normal flow of relay current and can be made large enough to provide some delay in the drop-out time of the secondary relay where this is desirable. This arrangement is particularly advantageous in keeping the two halves of the circuit electrically isolated from each other. The charge and discharge of C_1 on contact closure and on contact opening is shown in Fig. 3.

Camera Shutter Timer

By Hubert Sear

Mount Airy Road
Croton-on-Hudson, N. Y.

Most of the existing camera shutter timing devices make use of the moving-film or the ballistic galvanometer principle. In the development of the instrument described here, however, these ideas were avoided because of their relative expense, the time element with the former, and the difficulty in construction of the latter.

This instrument requires no critical set-up procedure. A light is placed behind the camera lens and the length of the flash transmitted when the shutter is snapped is measured. A photocell transforms this flash into an electric impulse which develops a voltage across the resistor R_1 as shown in the accompanying circuit diagram. This voltage is high enough to fire the neon bulb, which acts as a switch to the circuit R_2, R_3, developing a voltage across R_3. One half of the 6SN7 is thus biased to a predetermined value making it conduct a constant known current.

When the light on the photocell is extinguished by the closing of the camera shutter, the firing voltage for the neon bulb is removed and it goes out. This interrupts the current in the bias resistor R_3 and the triode section is returned to a non-conducting condition. This arrangement eliminates the necessity of a light source of regulated intensity.

Once the neon light switch is

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The bridge detector is composed of a single stage amplifier and an electron-ray visual null indicator. The detector is designed to be very sensitive when the bridge is at or near balance, but relatively insensitive when off balance.

A new zero-compensating circuit has been developed to provide marked improvement over previous bridges of this general type when making measurements below 1000 micromicrofarads.

For measurements on electrolytic condensers, a polarizing voltage, up to 500 volts, may be applied, from a grounded power supply if desired. Terminal capacitances of the power supply do not affect the accuracy of the bridge.

The bridge and its accuracy are unaffected by temperature and humidity variations over normal room conditions (65 deg. F. and 0 to 90% RH).

The ac-voltage applied to the capacitance under test varies from approximately 125 volts at 100 micromicrofarads to less than 3 volts at 10,000 microfarads.

This bridge combines all of the principal operating features of our popular Type 740-B and Type 740-BG bridges but improves the performance of each in most of their important characteristics.

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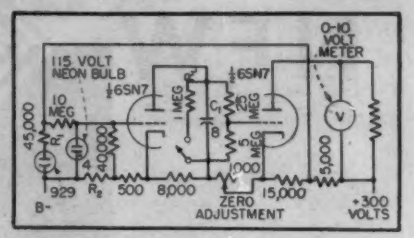
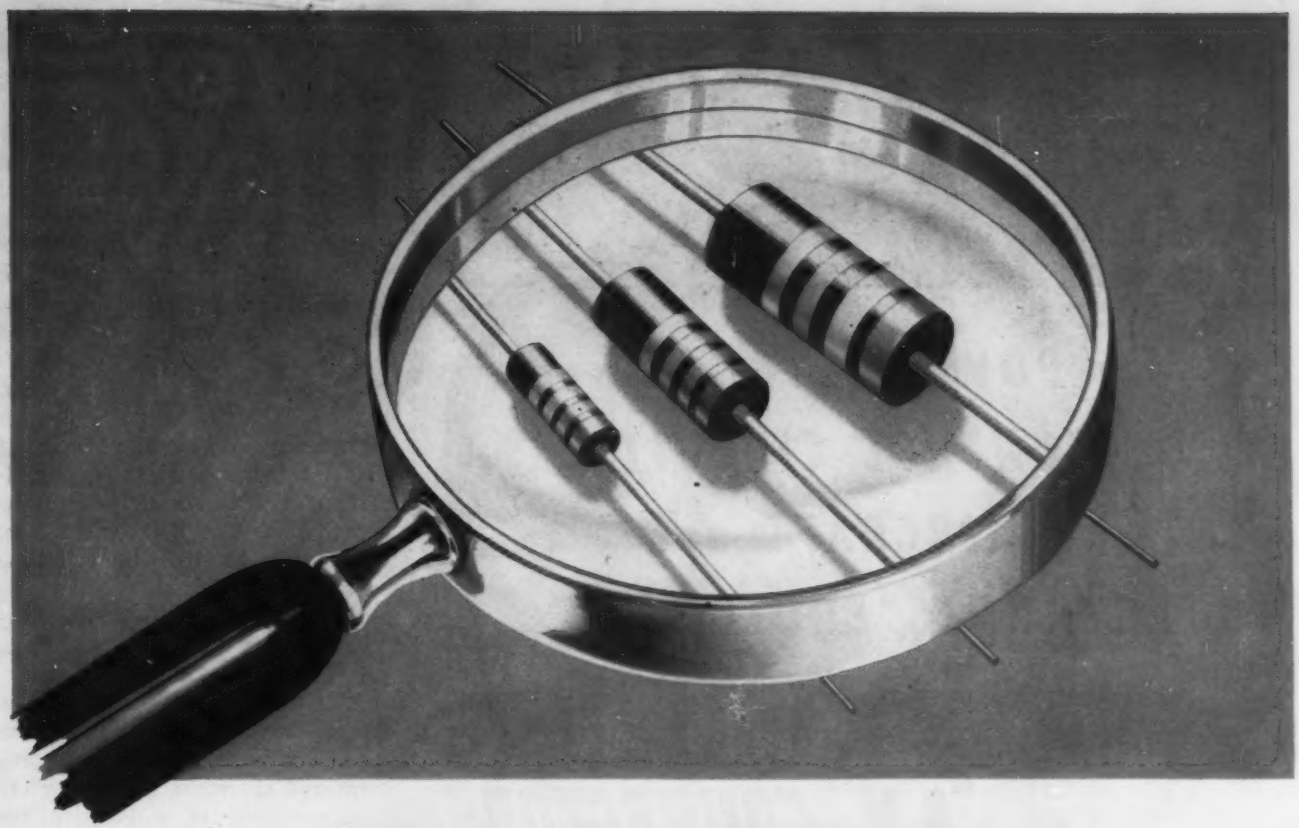


Schematic diagram for electronic shutter timer. The 0-10 voltmeter shows shutter time directly in seconds

closed, a constant bias is applied to the triode regardless of the size of the photocell current. Therefore the magnitude of the plate current is constant for as long as it is permitted to flow by the light flash. The voltage drop across the plate resistor charges capacitor C_1. This charging proceeds slowly because of the long time constant of this R-C circuit. In usual operation the capacitor is never completely charged. When the plate current is extinguished, the capacitor slowly discharges through the plate resistor causing a voltage to appear across it, proportional to the charge. Since the charge depends on the duration of the charging pulse, the voltage across the capacitor is proportional to the duration of that pulse, or the duration of shutter opening. This discharge voltage is taken from part of the plate resistor and applied to the grid of the second half of the 6SN7 used as a d-c amplifier. A voltmeter in this plate circuit indicates shutter speed directly in seconds.

The grid voltage for this last stage is not taken across the whole plate resistor since such a high resistance in the grid circuit would cause appreciable drifting due to the grid current. If adjusted correctly with the values shown, sufficient voltage may be obtained across part of this resistor without appreciable grid current effect. Grid current in the first stage prevents the use of this R-C circuit in its grid. Three selenium rectifiers are used in a voltage tripler circuit to furnish the high voltage (about 300 volts) which is necessary for proper biasing of the d-c amplifier. An ordinary gooseneck desk lamp has been used satisfactorily with the unit described.

Because of tube variables and other changes common with d-c



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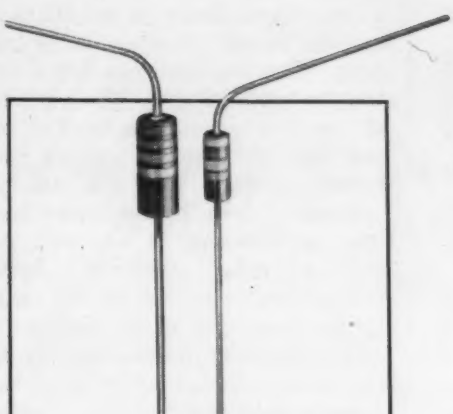

SIZES OF UNITS		
Rating	L	D
½-w	3/8″	9/64″
1-w	9/16″	7/32″
2-w	11/16″	5/16″

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2-watt rating—10.0 ohms to 22 megohms

Bradleyunits will operate at full rating for 1000 hours at 70 C ambient temperature with a resistance change of less than 5%. They require no wax impregnation to pass salt-water immersion tests and have high mechanical strength and permanent characteristics. Let us send you a complete Allen-Bradley resistor chart.

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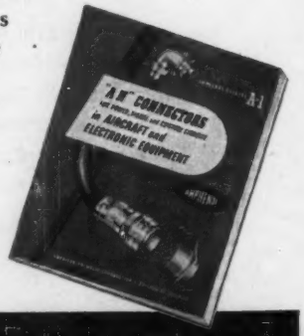

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amplifiers, the zero point must be reset about once a day. A low resistance R_L is also included to be switched in parallel with the high resistance of the R-C circuit so that the meter needle may be returned to zero more quickly than the natural discharge would allow. A type 929 photocell is used in preference to the higher output gas types because the speed of response is better.

Although the accuracy of the device is good enough for shop work, the difficulties inherent in d-c devices using vacuum tubes make it inadvisable for more exacting applications. Furthermore, due to the dependance on an R-C combination, the range is limited. Shorter time constants would cause the meter to move too fast to be read. The combination shown may be used from about 1/10 to 1/350 second.

A more versatile device now under consideration has an extended range and is an a-c instrument and therefore not subject to the inaccuracy of a d-c amplifier and hence is more suitable for the laboratory. It is, however, less suitable for a repair shop because it is also more expensive. An r-f oscillator suitably isolated and crystal stabilized, feeds its output to a scaling circuit through a gating tube. The impulses are gated by the photocell voltage. The number of impulses passed is a function of the time the light is passing the opened shutter. They are counted and scaled down by the scaler and may be indicated in any suitable manner. The range of speeds measurable is limited on one hand by the frequency of the oscillator, and on the other by the capacity of the scaler. Both may be extended almost indefinitely with circuits now available.

Telecontrolled Clocks

CLOCKS connected directly to the 60-cycle line are self-regulated electronically without special clock wiring in a development by International Business Machines Corporation. Each clock is checked individually and automatically once an hour for uniformity with the system time. Should any of the clocks be out of step, owing to a current interruption, they will be corrected

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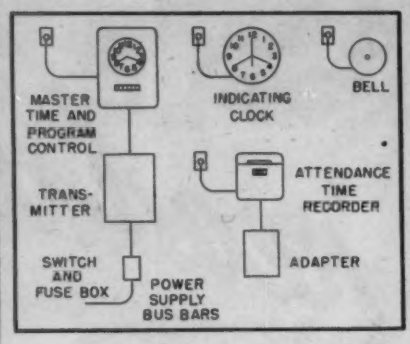

Electronic system for synchronizing clocks, signal units, time stamps and recorders

once an hour up to 59 minutes slow and 55 seconds fast.

The new system would be a convenience to industrial concerns, schools, and hospitals.

In the new system, a master time control is installed and operated from the same alternating current to which the indicating clocks are connected. This control is the director of the entire system and keeps all units in agreement with it. Every hour electronic tube action in a transmitter at the control sends a supervisory impulse out over the power lines. A simple electronic receiver in each indicating clock accepts the impulse. If the clock is slower or faster than the master time control, it corrects itself once each hour automatically. If the clock is in agreement to the second to the master control, it continues to function as an independent clock. Thus, without special wiring, all clocks in a building show the same time.

This IBM system also permits automatic signaling, sounding of bells, horns, buzzers, gongs, or chimes, through the program unit of the master control, without special signal wiring. These signals are also fed to the line to actuate the electronic receivers when an impulse is released to them. Three different schedules of signals may be sounded without special wiring. Self-regulating minute impulse units, attendance time recorders, job cost recorders and time stamps, are operated by the system through use of an adapter. This adapter is connected to the line to receive the hourly corrective impulse sent out by the transmitter. After verifying its own agreement with the time of the master time control, the

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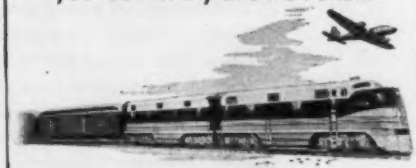

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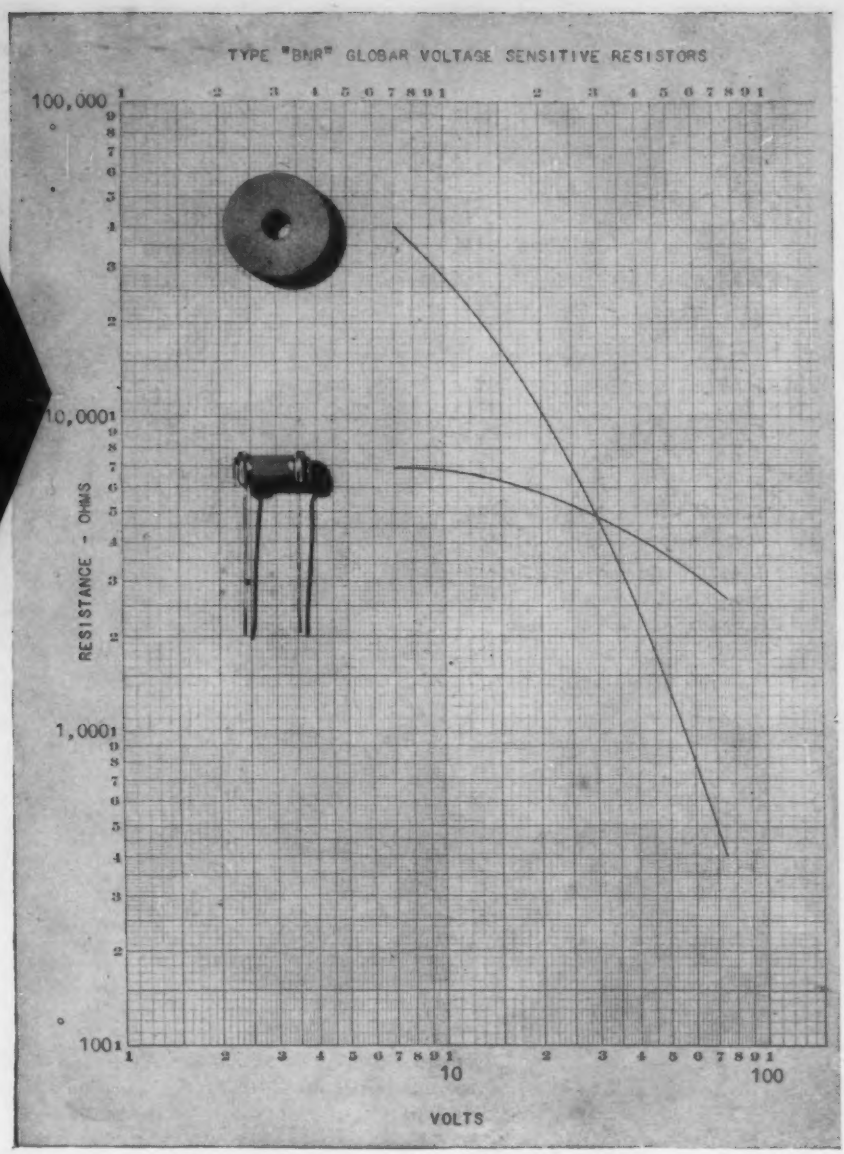
HOW Resistance-Voltage Characteristics are altered by Resistor Design



Here are negative resistance-voltage curves plotted for two GLOBAR type BNR RESISTORS. Both resistors are voltage sensitive. However, the two curves coincide at one point only, namely, 30 volts. But, of more importance, observe how the difference in resistor design drastically alters its characteristics. Note the effect a change in the shape of the resistor has on the slope of its resistance-voltage curve. Fundamentally, this change in characteristics is accomplished by altering the specific resistance of the resistor.

Graphically presented here, this variance in characteristics—caused by resistor design points up an important factor in specifying and ordering GLOBAR resistors to meet exact needs of specific applications. It is a good reason why GLOBAR resistors are not carried in stock, but are quickly made to your requirements.

To save time and trouble in producing for you voltage sensitive resistors that will do the job for which they are intended, we ask only that you furnish a few simple facts. Briefly tabulated, this necessary information is:

1. Type of apparatus in which the resistors are to be used.
2. Method of mounting and space limitations.
3. Normal operating voltage and peak voltage if available.
4. Resistance and inductance of the circuit if available.
5. Ohmic resistance of the resistor and allowable plus and minus tolerance.
6. Maximum voltage applied continuously or intermittently.
7. Duration of load and elapse of time between its application.

For your engineering tests, we can furnish samples in a hurry. For any information that may be helpful in working out your resistor problems, write Dept. V-108, The Carborundum Company, GLOBAR Division, Niagara Falls, N.Y.

GLOBAR Ceramic Resistors
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SPECIFICATIONS

BALLANTINE MODEL 300 ELECTRONIC VOLTMETER

RANGE: .001 to 100 Volts, r.m.s. (.00001 to 10,000 Volts, with accessories)

ACCURACY: ±2% at any point on the scale.

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METER: Logarithmic Voltage scale and uniform decibel scale.

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MODEL 220 DECADE AMPLIFIER

MODEL 402 MULTIPLIER

The Model 300 Voltmeter is a valuable tool for measurements in communication and "weak current" engineering. Its unusual sensitivity, accuracy and stability make it ideal for work in the audio, carrier, and supersonic ranges. Logarithmic meter indication assures uniform accuracy of reading over the whole scale while permitting range switching in decade steps. There is but one scale to read for all ranges. Output jack and output control are provided so that the voltmeter can be used as a high-gain stable amplifier.

Accessories include Model 220 Decade Amplifier, which supplies standardized gains of 10x and 100x, and the Model 402 Multipliers which supply additional ranges of 1,000 and 10,000 Volts.

Descriptive Bulletin No. 12 Available

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY, U. S. A.

adapter then proceeds to verify the agreement of the minute impulse units with itself and to correct any variations from accurate time which might have occurred in them during the preceding hour.

Sound Flashlight for the Blind

BY VICTOR TWERSKY

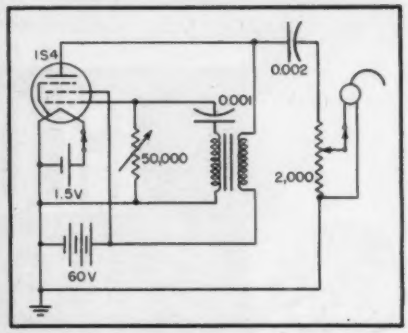
Technical Adviser, Guidance Device Project
Biology Department
City College of New York
New York

VARIOUS obstacle-detecting devices to aid the blind in foot travel are being studied by research laboratories. A group of students from the City College of New York have developed a relatively simple "sound flashlight" which has proved successful in aiding sightless persons to detect and avoid objects in walking which might otherwise be discovered by collision.

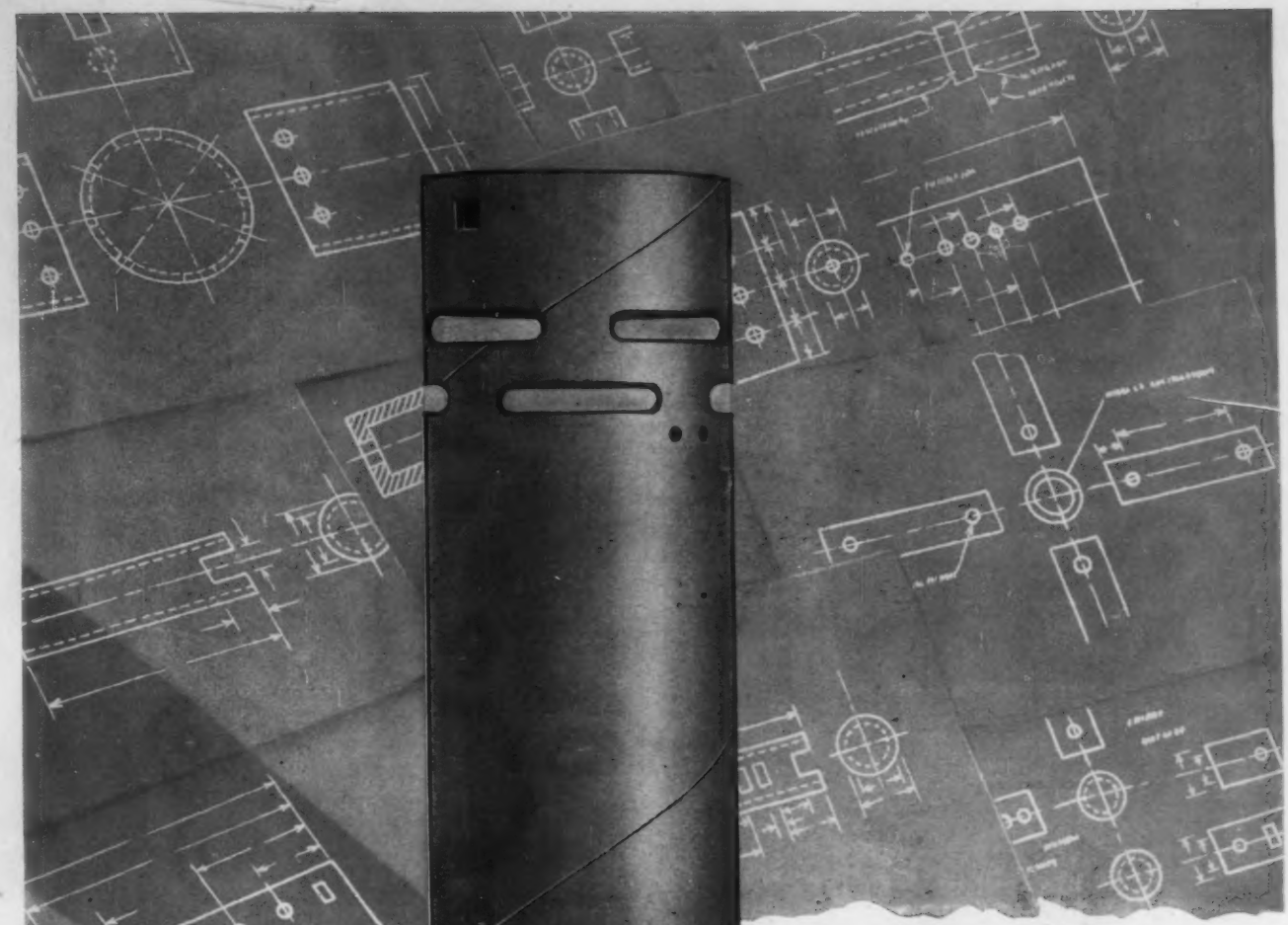
Similar in size and shape to a large flashlight, the unit is carried by the blind person with a scanning motion. Sound waves projected from the unit in a narrow beam are reflected by solid objects, and the reflected sound warns the user of the object's presence.

The heart of the unit is a single-tube oscillator powered by hearing-aid batteries. The circuit is shown in the accompanying schematic diagram. A headphone unit was chosen for the transducer, and its inductance in conjunction with the 0.002-μf capacitor form a resonant circuit for the desired frequency range between 8 kc and 15 kc.

The choice of this range of frequencies was guided by the consideration of reflection and interference from ambient noises which might be encountered out of doors. It was found advisable to make the frequency adjustable to allow



Complete circuit of the obstacle-detecting oscillator



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The heart of the Outdoorsman *Castomatic reel illustrated above is but one of many gear trains developed by our engineers and produced in our fully equipped plant.*

Quaker City Gear Works
INCORPORATED
1910 N. Front Street, Philadelphia 22, Pa.

In appearance, the sound flashlight resembles the conventional type

changes for different conditions and for relief of ear fatigue. Experimenters noticed that sound at frequencies below 10 kc attracted considerable undesired attention from bystanders.

Beam widths between 12 and 30 degrees (depending on frequency) are possible with the reflector which is 4 inches in axial length and 4 inches in diameter at the mouth. The reflector is made of spun aluminum covered with papier maché.

The headphone transducer is mounted at the focal point of the reflector. It is insulated from the metallic reflector by a layer of sponge rubber and held in place by rubber cement and papier maché. A male plug is embedded in the rear of the horn for connection of the extension cord from the oscillator which is carried in a pocket.

To reduce the intensity of the sound reaching the user caused by leakage around the rim, baffles of cotton and sponge rubber are used with only slight reduction in the intensity of the main lobe.

Although the sound flashlight was designed primarily as an obstacle detector, skilled operators

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NATURALLY you want to profit from the zooming demand for electronic heaters for high-speed repetitive work. And knowing it's the oscillator tube that makes or mars performance, you intend to be extra-careful about tube high frequency—ample capacity in watts—reliability that users can bank on—availability *you* can bank on!

These qualities are packaged in Type GL-592. The tube already is in service, helping to speed plant output. Stocks are on hand to meet your requirements, and sockets, grid connectors, finned anode connectors, all are available. *Specify and install*... there'll be no lag between the two!

That high frequency ceiling (150 mc at full ratings) means Type GL-592 will handle easily the up-to-70-mc requirements of bench dielectric heaters, not to mention lower-frequency induction work. The tube carries substantial plate ratings, and if still more power is desired, a pair or two pairs may be employed without prohibitive increase in cost or size of the equipment. Conversion efficiencies above 70 percent are routine for the GL-592 in properly designed circuits. Cooling calls for merely an 8-inch household-type fan, or a small and inexpensive pressure blower.

The tube is sturdy—cathode, grid, and anode are solidly mounted and braced. All leads are short. Fernico metal-to-glass seals mean (1) no cemented caps or bases with the dielectric losses these entail, (2) no soft-soldered leads or terminals to come loose.

Get further facts about this modern, efficient, *tough* triode—including the favorable price—from your nearby G-E electronics office! Or wire or write *Electronics Department, General Electric Company, Schenectady 5, New York.*

GL-592
Power Triode

Ratings, Class C Power Amplifier and Oscillator

Filament voltage		10 v
current		5 amp
Max ratings:	CCS	ICAS
d-c plate voltage	3,500 v	3,500 v
d-c grid voltage	—500 v	—500 v
d-c plate current	250 ma	350 ma
d-c grid current	50 ma	100 ma
plate input	670 w	1,000 w
plate dissipation	200 w	300 w
Type of cooling		forced-air
Frequency at max ratings		150 mc

The G-E line of power triodes for electronic heating is complete, covering every need and application. Tube types range in max plate voltage from 2,000 v to 20,000 v—max current, from 250 ma to 10 amp—max dissipation, from 125 w to 100 kw. Prices and details on any or all types will be supplied at your request.

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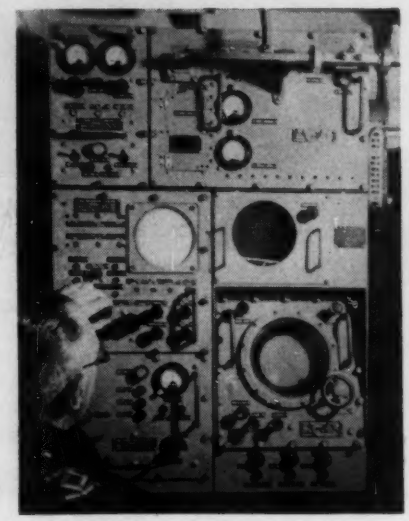
have been able to detect slight depressions by directing the beam so that it makes an angle of about 60 degrees with the ground. The device is most successful, however, in detecting such obstructions as trees, lamp posts, parked vehicles, hedges, flights of stairs leading up, and open doorways.

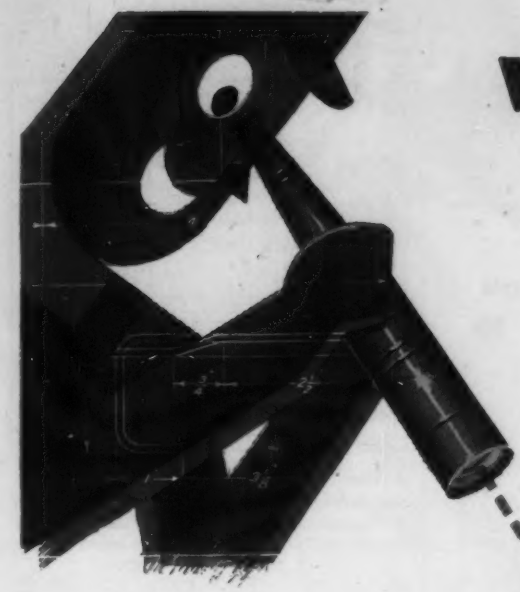
Preliminary tests showed that detection was possible at distances up to and greater than 30 feet, depending on the number of obstacles present, the prevailing acoustical conditions and the user's experience and proficiency.

RADAR-EQUIPPED LINER BERTHS IN FOG



Radar installation in iron hutch atop navigation bridge of 20,000-ton Canadian Pacific line's "Empress of Canada" with plan position indicator screen just above operator's head. Repeater tube is located on navigation bridge for use by captain and pilot, who keep in contact with the trained radar operator by telephone when interpretation of complex patterns is required

View of "Empress of Canada" running into fog in the Mersey. This ship recently came into Liverpool harbor in total fog and reached her berth entirely by radar. The landing stage could be seen by the crew only after they had gone half-way down the gangplank. The ship is fitted with British Admiralty type 268 radar



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No changing of needle pressure
. . Nothing else to do!

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2. Permanent Sapphire Needle with .001" Tip Radius.
3. Approximately One-Half Volt Output.
4. Frequency Range 30 to 10,000 c. p. s.
5. Novel Design at Base Eliminates Tone Arm Resonances and Assures Perfect Tracking.
6. LP-33 Cartridge for Microgroove instantly replaceable in FL Arm with LP-78 Cartridge having .003" radius needle for playing 78 RPM Records. Both simply slip into position, no tools needed, NO CHANGING OF NEEDLE PRESSURE.

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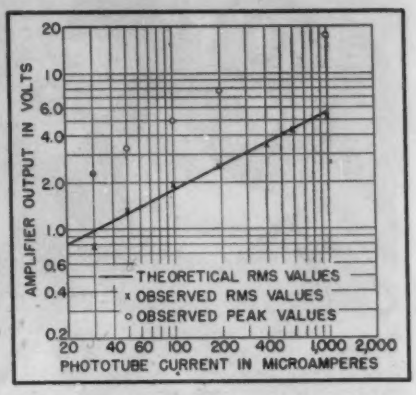
Astatic Crystal Devices Manufactured Under Brush Development Co. Patents

THE Astatic CORPORATION CONNEAUT OHIO

(continued from p 126)



Agreement of observed and theoretical rms noise voltages indicates that, over the measured range, shot effect is the only important contribution to the noise output of vacuum phototubes

statistics, which gives[1] $\delta = N_o^{-1/2}$ where N_o is the average number of electrons emitted in the interval T seconds. The mean fluctuation Δ is equal to the product of the mean relative fluctuation and the average number of electrons emitted during the interval, or $\Delta = N_o^{1/2}$. This result implies that the random variation in phototube current (noise) is proportional to the square root of the phototube current, if every electron that is emitted by the cathode reaches the anode.

When a phototube provides the input signal to an amplifier, the output of the amplifier consists of the shot noise from the phototube and the thermal noise from the input resistance of the amplifier, assuming that subsequent stages in the amplifier contribute relatively negligible noise. If the characteristics of the amplifier are known, the noise contribution of the phototube can be calculated from the measured noise output.

Effect of Amplifier

The mean-square voltage across the output terminals of an amplifier is given by[3]

$$V_N^2 = 2ei \int_0^\infty Z^2 G^2 df$$

in which V_N is the rms noise voltage, e the change on an electron (1.59×10^{-19} coulomb), i the phototube current in amperes, Z the phototube coupling impedance in ohms, G the voltage gain of the amplifier, and f is frequency in cycles per second. Inasmuch as G is a function of frequency, this

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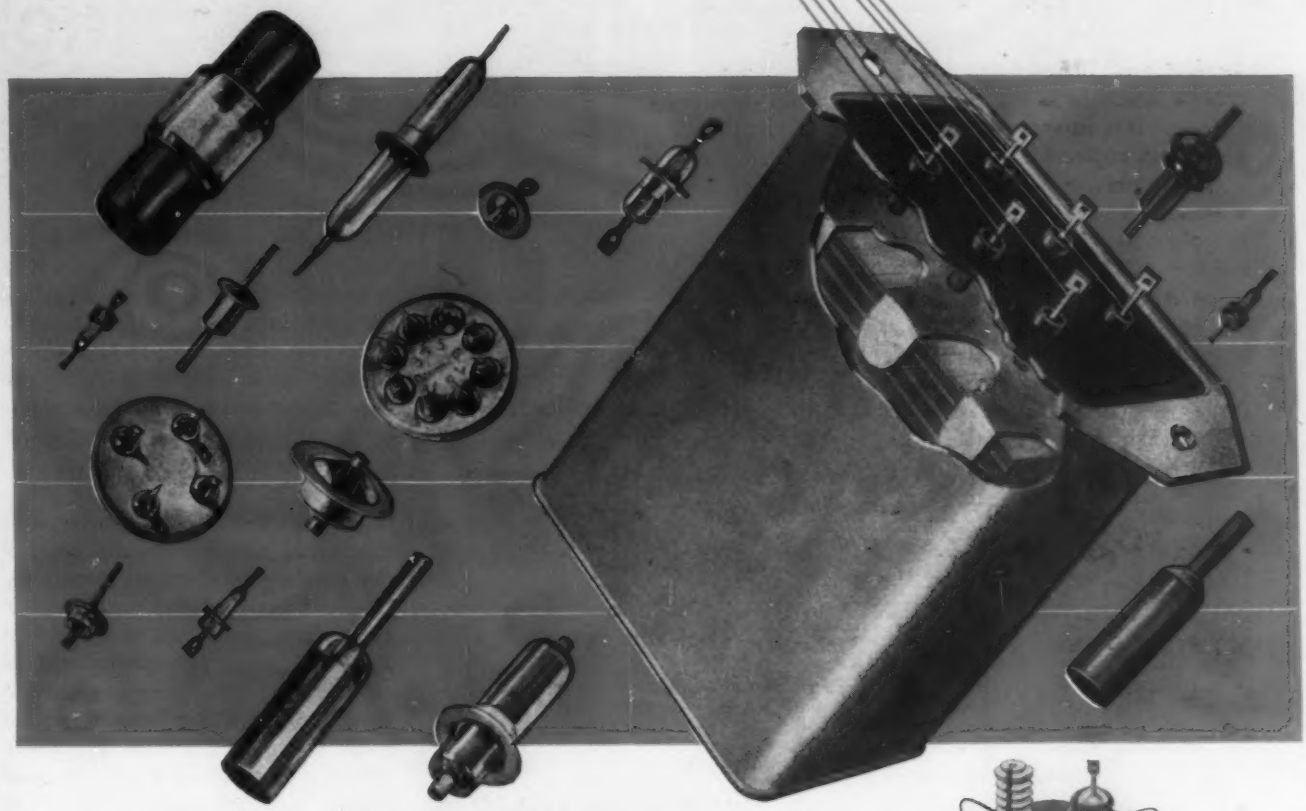

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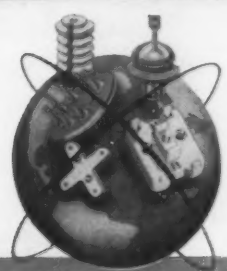

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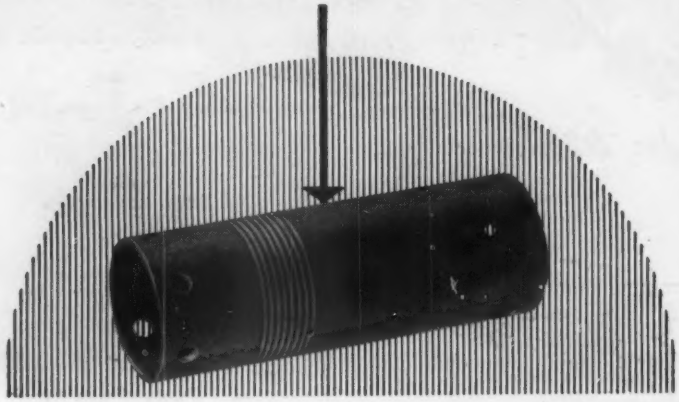

equation indicates that the noise output is proportional to the square root of the amplifier bandwidth. The noise due to the amplifier can therefore be reduced by making the pass band of the amplifier as narrow as other design considerations permit.

Effective Noise Bandwidth of Tuned Amplifiers

Number of stages	*Bandwidth factor*
1	1.57
2	1.22
3	1.15
4	1.13
5	1.11
6	1.10
infinity	1.06

Effective noise bandwidth of an amplifier consisting of cascaded, independent, identical, single-tuned pentode stages is the product of the overall half-power bandwidth of the amplifier and the above bandwidth factor for the appropriate number of stages

Usually in computing the noise contribution of an amplifier, the bandpass characteristic, including the skirts out to −6 db of the midband transmission, is measured and the frequency-gain area corresponding to a rectangular bandpass obtained to simplify the calculation. A rigorous approach[4] shows that the noise bandwidth equals the overall half-power bandwidth of the amplifier times a factor which is a function of the number of stages, as given in the table. This bandwidth factor accounts for the skirt shape and indicates that increasing the number of identical stages, up to about three stages, produces an appreciable reduction in equivalent noise bandwidth for circuits of fixed selectivity. On these considerations an amplifier consisting of three tuned stages with a cathode follower output was built. A peak gain of approximately 9×10^4 at 395 kc was obtained.

Experimental Method

The input circuit to the amplifier consisted of the phototube and its load resistor in parallel with the amplifier input impedance. The coupling impedance Z was measured to be 21,000 ohms to within 5

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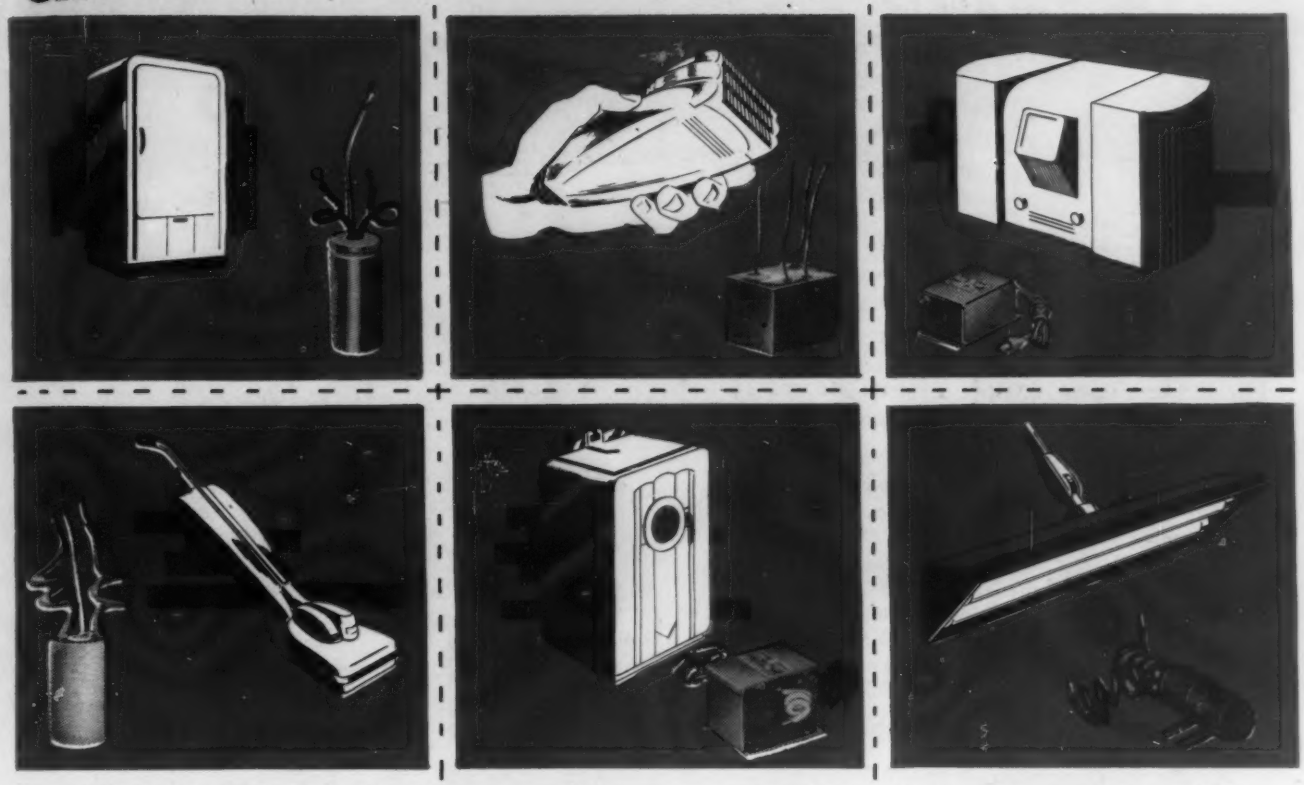

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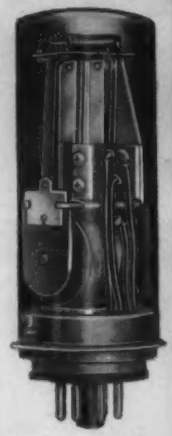
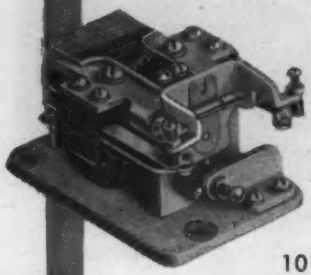


Perhaps you have an electronic circuit where a change in voltage or current requires the switching of several other circuits. The SENSITIVE MULTIPLE CONTACT PLUG-TYPE RELAY, illustrated at right, is designed to meet just such a condition and offers up to 6 pole, double throw, with a 20 point plug. A.C. or D.C. Ask for Bulletin 50-6.



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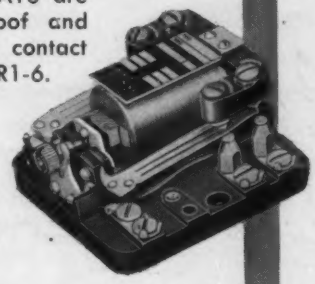
A keying circuit or pulsing circuit where rapid response and low current drain are required characteristics. The SERIES 10 AND SERIES 20 RELAYS are fast, sensitive, shockproof and are adaptable to many contact arrangements. Bulletin KR1-6.



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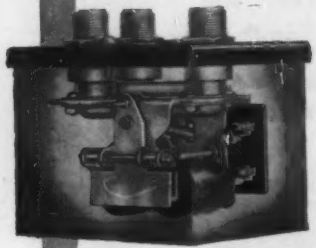

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percent; this impedance can be considered constant over bandwidth.

The phototube used in these measurements was a GE 1P24. Several tubes were tested and little difference between them was found.

The output voltage from the amplifier was measured by two methods: a vacuum thermocouple with a 3,000-ohm resistor in series indicated the rms value of the output, while a vacuum-tube voltmeter was used to measure peak voltage. (The vtvm was a peak reading instrument calibrated in rms value of a sine wave, which is 0.707 of the peak. Therefore the actual meter readings were multiplied by 1.414 to obtain peak values.) The thermocouple output is fed to a galvanometer. The combination was calibrated at 395 kc and checked at 300 and 500 kc, at which frequencies the calibration was little changed from the center-frequency value.

Theoretical values of the noise output of the amplifier were obtained from the foregoing equation using the measured value of Z. The expression

$$\int_0^\infty G^2 df$$

was evaluated by numerical integration of the measured response of the amplifier, with squared ordinates. Substituting the numerical values in the equation for noise gave $V_N^2 = 3.0 \times 10^4 i$ square volts, where i is the phototube current.

Theoretical and observed values for V_N are shown in the graph. Observed values were corrected for residual amplifier noise by means of the relationship

$$V_N = (V_o^2 - V_R^2)^{1/2}$$

where V_o is the measured amplifier output voltage with noise signal from the phototube applied and V_R is the residual noise with no applied signal. The residual noise amounted to about 0.3 rms volt. The close agreement between theoretical and observed values indicates that other sources of noise contribute very little to the noise output.

Observed peak values are also plotted on the graph. The peak voltage is about three times the rms value. This represents considerable departure from sinusoidal waveshape for which the peak value is 1.414 times the rms value. (Something about the impulse waveform

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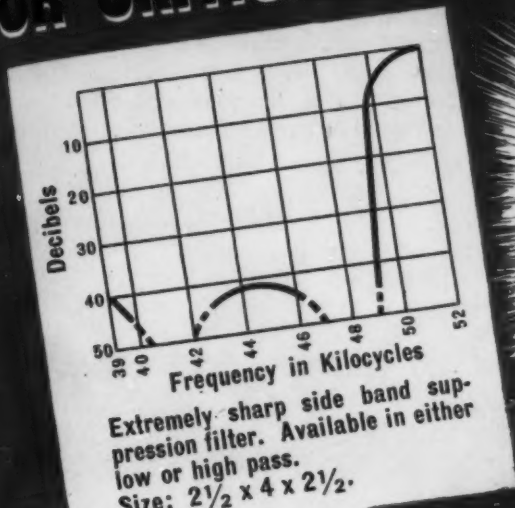

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Size: 2½ x 4 x 2½.

Sub-miniature band pass.
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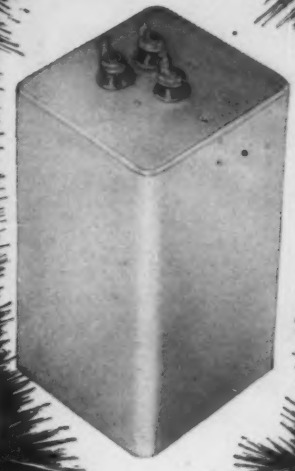

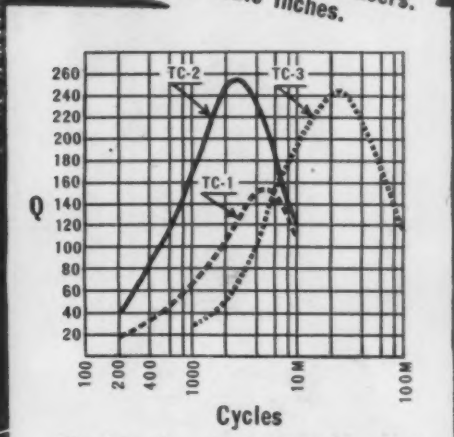

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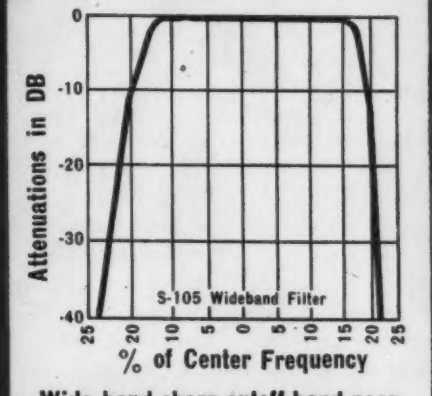
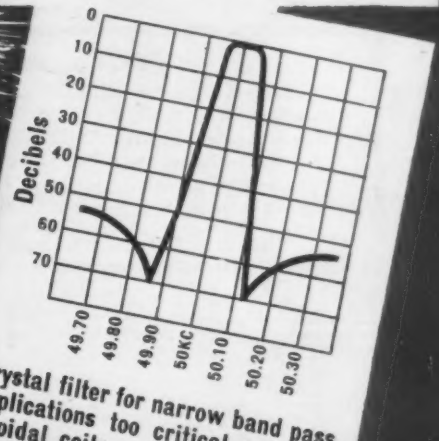
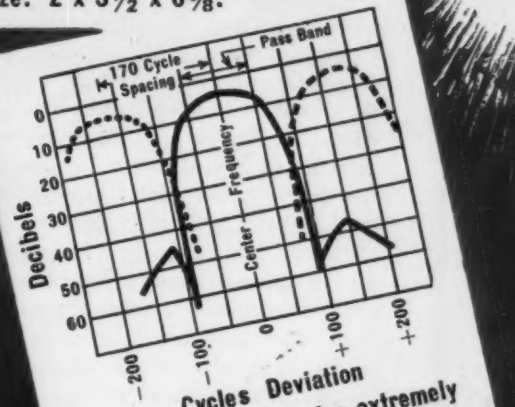


Wide band sharp cutoff band pass.
Size: 2 x 3½ x 6⅝.



Crystal filter for narrow band pass applications too critical even for toroidal coils.



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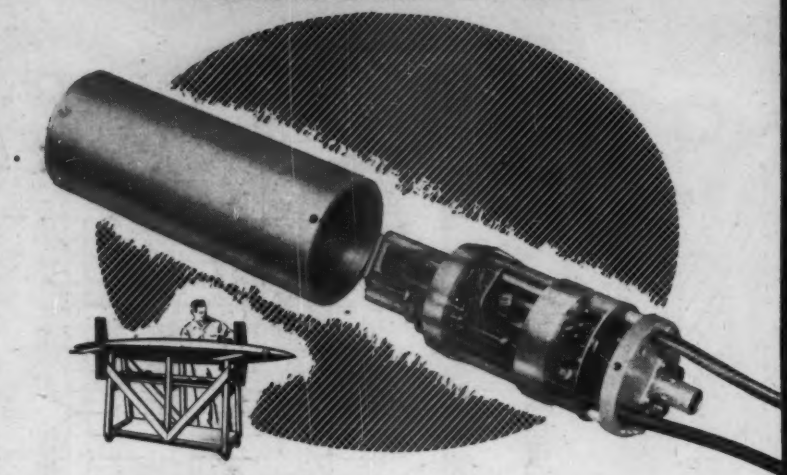

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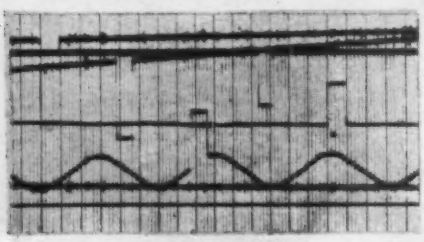
Power required: 135 volts at 40 ma and 6 volts at 0.45 amp.
Nominal output: 0.5 watt into 51.5 ohms
Weight: .875 pounds
Case Dimensions: 2 inches in diameter–5⅛ inches long (excluding connectors)



DATA REDUCTION

Additional information on the TXV-2A Transmitter or other telemetering components or services is available upon request from qualified companies.

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of the noise could be inferred from this factor of three, but would have little significance without further measurements.)

Conclusions

From these observations it is concluded that the noise output from vacuum phototubes is almost entirely due to shot effect for currents up to at least one milliampere, and can be calculated simply and accurately. The fact that the peak to rms ratio is higher for the noise signal than for a sinewave is important in applications where the response to peak voltage is being used.

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(1) A. L. Hughes and L. A. DuBridge, "Photoelectric Phenomena," p 34, McGraw-Hill Book Co., 1932.

(2) B. A. Kingsbury, The Shot Effect in Photoelectric Currents, *Physical Review*, 38, p 1458, 1931.

(3) J. B. Johnson and F. B. Llewellyn, Limits to Amplification, *Electrical Engineering*, 53, p 1449, 1934.

(4) Henry Wallman, Stagger-Tuned I-F Amplifiers, *MIT Rad. Lab. Report No. 524*. (The factors for 1, 2, 3, and 4 stages were independently determined by I. Rotkin and P. R. Karr of NBS and reported by them at the October 1947 meeting of URSI in Washington.)

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WHY---

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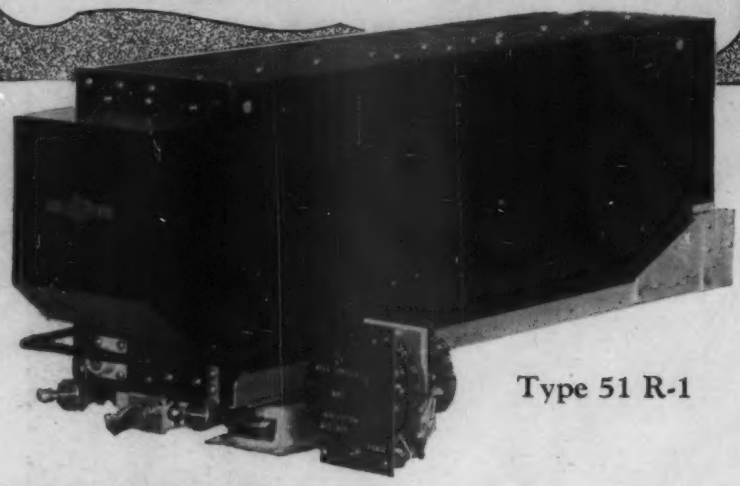


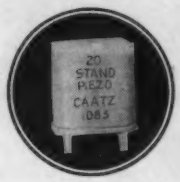
Type 51 R-1

PROBLEM

To build a receiver intended for airline and military service in the vhf navigation and communication bands. Compactness and elimination of extra weight dictated use of a crystal that is light in weight, hermetically sealed and highly stable.

SOLUTION

STANDARD'S Crystal-Type 20



REASONS

(as stated by Collins Engineering Department)

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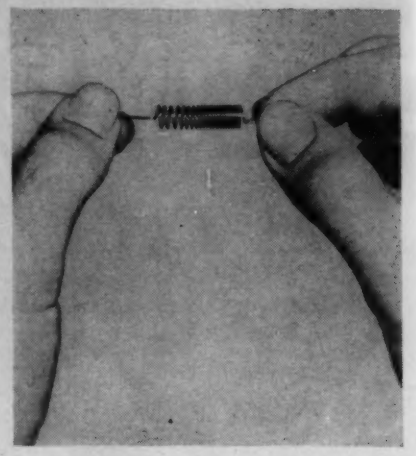


Basis of sensitive mechanoelectrical transducer is progressive separation of turns under increasing tension. Unloaded resistance is that of a solid cylinder because of low contact resistance between gold plating on coils and high average initial tension of the spring

sure elements, accelerometers, weighing devices, temperature controllers, and other measurements involving changes in dimensions. The preferable construction for a transducer using such springs is a four-arm bridge in which a displacement elongates one pair and shortens the other pair of springs. Measurements with this circuit are reproducible to one percent.

Reducing Hum in Pentodes

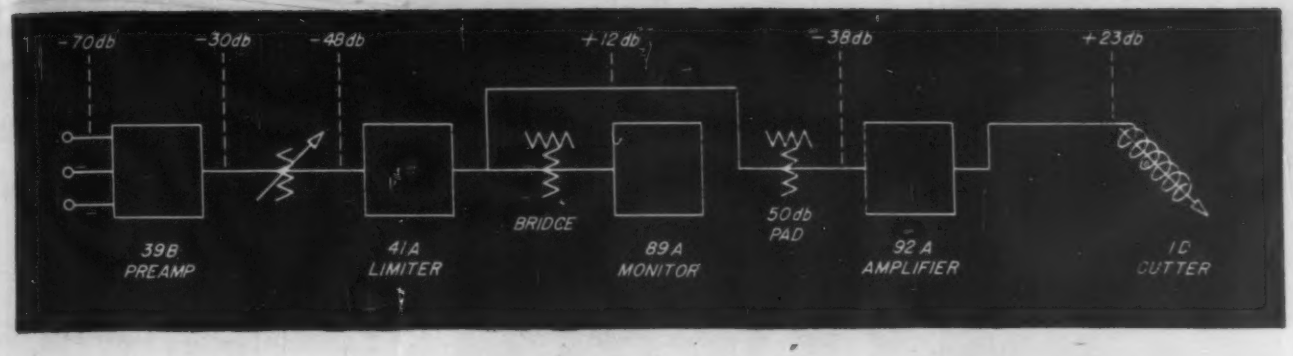
By IMRE ZAKARIAS

Picofarad Elektromos Meroberendezesek Budapest, Hungary

USING SCREEN-GRID TUBES for amplifying low-level signals of the order of ten microvolts having frequency components in the band from 0.5 to 200 cycles per second, as in equipment for electrocardiography and electroencephalography, is troublesome because of the residual hum from the alternating current used in the heaters, despite screening, filtering, and grounding of the cathode. Tests show that this heater hum varies with tube type and between individual tubes of the same type. To find means for counteracting this source of hum, measurements were made which showed the effectiveness of the several alternatives.

Sources and Measurement of Hum

If there is a potential difference between cathode and heater, as in



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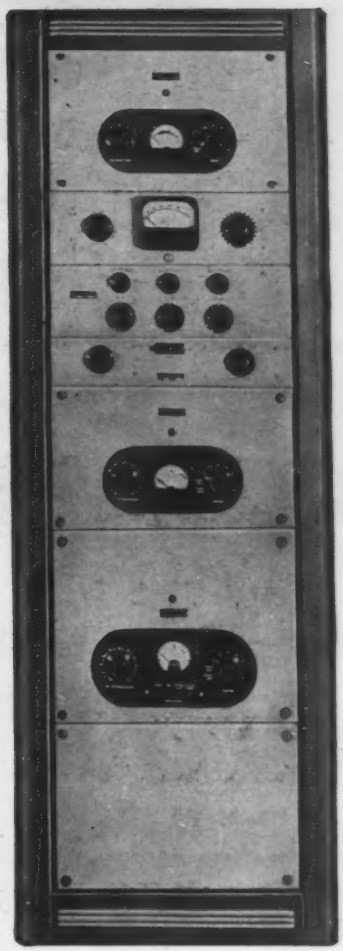

Pictured here is an all-Presto single channel recording system. Above is the block diagram, worked out for this equipment by Presto engineers.

WHEN YOU NEED recording or transcription equipment you can't go wrong if you make the complete system 100% Presto.

For Presto is the world's foremost manufacturer of recording and transcription equipment and discs. And Presto's experience with countless installations, including all the big ones, will aid you in achieving greater efficiency and trouble-free operation.

The recorder is the 8DG with direct gear drive. The amplifiers are the 39-B three channel preamp, the 41-A limiter, the 92-A 60 watt recording amplifier, and the 89-A monitor.

Multiple channel installations consist of as many duplications of the basic channel as are needed with the addition of switch or patching facilities. When you think of recording, think-of PRESTO.

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Paramus, New Jersey

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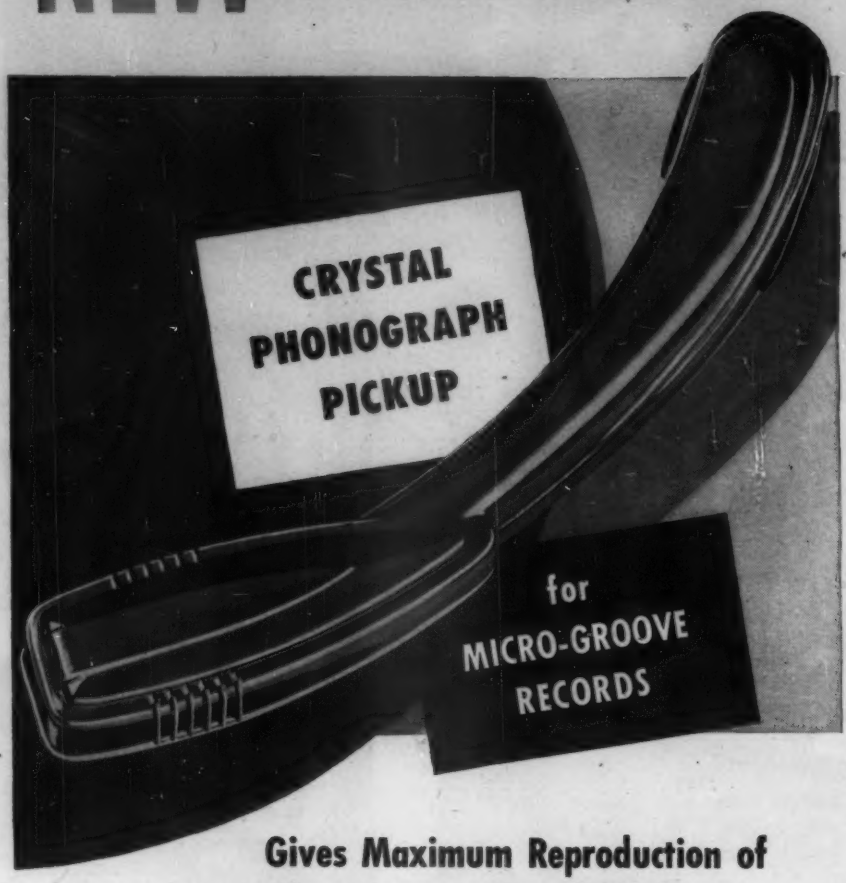
WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT AND DISCS

NEW SHURE "900MG"



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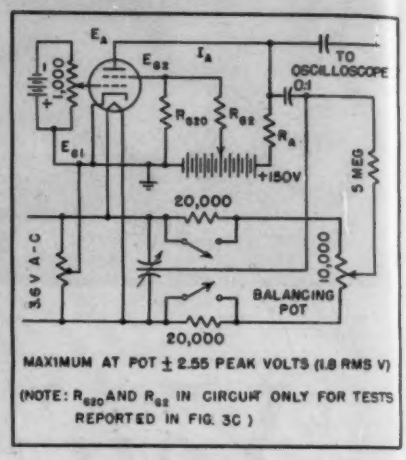


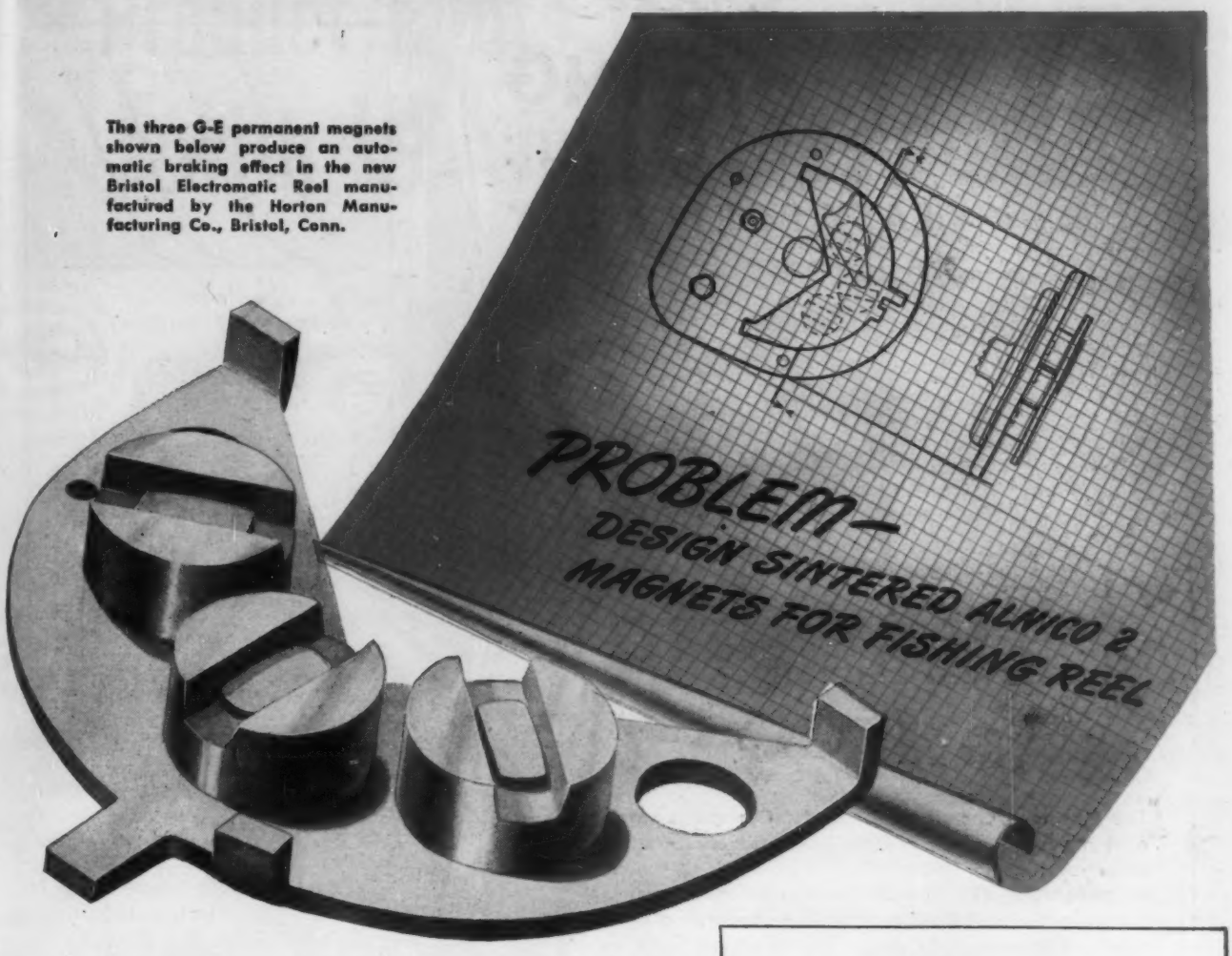
FIG. 1—Experimental circuit for measuring hum produced by heater current

self-biased circuits and in which case the cathode is not grounded, a portion of the hum can arise from leakage currents between heater and cathode. But usually the hum results from the fluctuations of the current distribution between screen grid and plate caused by the deflection effect of the alternating magnetic field of the heater current. Tests in which the tube was heated by direct current and an auxiliary alternating potential of six volts was applied between heater and cathode, with the cathode grounded, showed no hum. Also, the hum disappeared when the screen was connected directly to the plate, with a-c heating. Furthermore, the hum was found to be up to 40 fold greater in a variable-mu tube such as an AF 3 (comparable to a 58) compared to a sharp cutoff tube such as the AF 7 (like a 57). It was also observed that the hum varies with the operating point so that varying the control or screen bias can cause the hum to pass through zero, and that an unbypassed screen biasing resistor tends to increase hum whereas an unbypassed cathode resistor tends to decrease it.

In making these measurements of power line hum, the compensating method was used. A voltage, derived from the heater circuit by means of a wired potentiometer, for controlling magnitude, and a differential capacitor, for adjusting phase, was impressed on the plate of the tube under test. The normal operating voltages for the tube were obtained from batteries; Fig. 1

YOU GET QUALITY PLUS ENGINEERING SERVICE WITH G-E PERMANENT MAGNETS

The three G-E permanent magnets shown below produce an automatic braking effect in the new Bristol Electromatic Reel manufactured by the Horton Manufacturing Co., Bristol, Conn.



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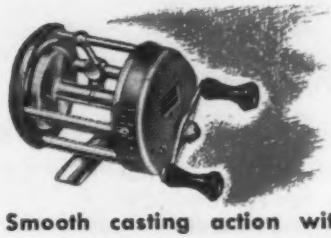
Now it's G-E permanent magnets for greater accuracy in casting. The permanent magnets shown above develop a non-friction braking action directly in proportion to the speed of the plug. Maximum braking is applied at the start of the cast and, as the spool is slowing down, the braking effect decreases automatically.

G-E permanent magnets are continually finding wide application in many fields. The magnetic reel is but one example of the adaptation of an industrial magnet engineering principle to an entirely different field.

Perhaps there's a use for G-E permanent magnets in your product. Or, you may wish to improve your present magnet design for greater efficiency. Our engineers will be glad to work with you to improve your product. For details and your free copy of CDM-1, G-E PERMANENT MAGNETS, *write Metallurgy Division, Section CM-11, Chemical Department, General Electric Company, Pittsfield, Mass.*



Smooth casting action with the Bristol Electromatic Reel

Three G-E Sintered Alnico magnets are mounted on a non-magnetic plate having adjustable air gap. A bi-metallic disc of copper and steel mounted on the end of the spool cuts the lines of force of the permanent magnets. The eddy currents induced set up electromagnetic poles which repel the permanent magnet poles producing a drag on the speed of the spool. Since the strength of the electromagnetic poles depends on the speed of rotation of the spool, this braking effect is automatically applied at all times in just the right amount. Outstanding advantages of this new reel are smooth casting action, greater accuracy, and freedom from backlash.

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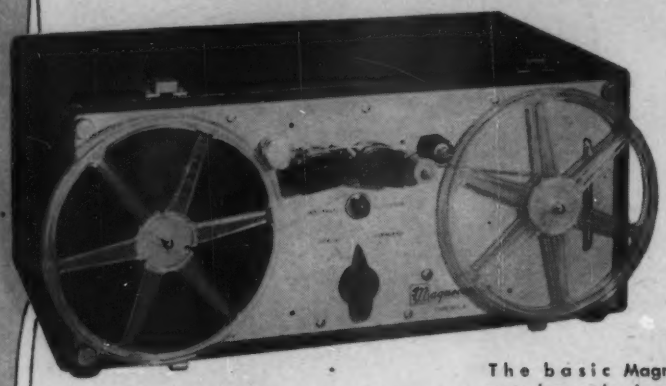

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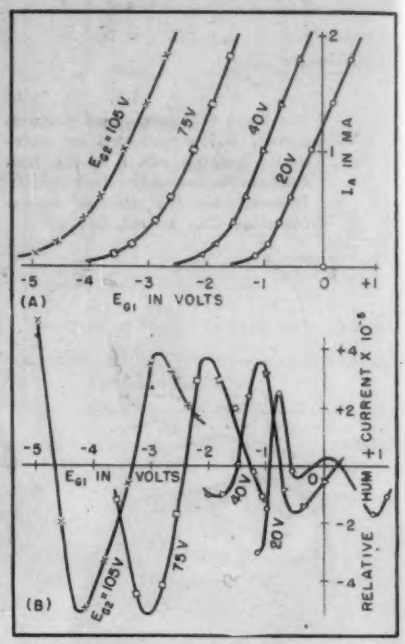

FIG. 2—Characteristics (A) and relative hum current in plate circuit (B) of a sharp cutoff pentode

shows the circuit. Balance in the plate circuit was indicated by a cathode-ray oscilloscope.

Experimental Method and Results

So that absolute values could be obtained, the deflection sensitivity of the oscilloscope and the volts per scale division of the balancing potentiometer were determined. Knowing these factors, the hum can be expressed in terms of alternating current in the plate circuit, or as the ratio of hum current to steady plate current. Shorting the two 0.02-meg resistors in series with the balancing potentiometer increased the compensating voltage by a factor of five. Although the differential capacitor was found necessary to eliminate minor phase shifts, it was observed that, in general, the hum was in phase with the heater voltage.

The results are presented in the form of curves. Figure 2A is the measured characteristic of the AF 7 tube used in the tests. Figure 2B shows the ratio of hum to steady plate current as a function of control grid voltage for four values of screen-grid voltage. Figure 3A shows the same measurements plotted as a function of plate current. In interpreting the effects shown in these last two families of curves,

Product faults found in minutes with MB vibration exciters!

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There's no practical lower limit on the amplitude of vibration you can detect with the MB Vibration Pickup—it's that sensitive! And there's no engine it can't be used on — it's that durable under high-powered pulsations!

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Ask for bulletin "Vibration Testing Technique" which describes how MB Exciters are used. And Bulletin 124A will give you more details on Pickup. Write Dep't. D5.

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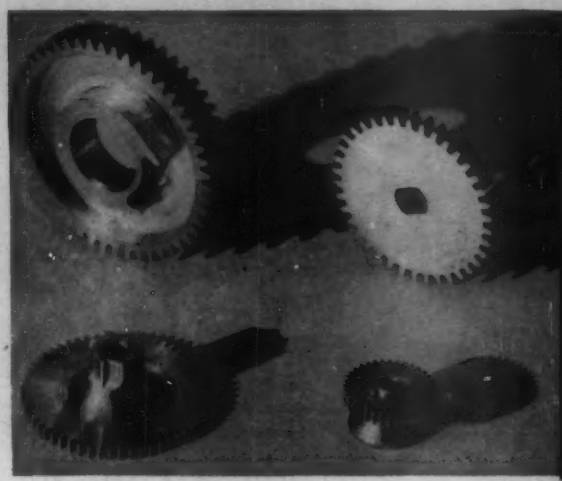

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Within 1% for voltage between 30-500 volts, from no load to full load.
Within 1% for line voltage variations from 105 to 125 volts at full load current for any voltage between 30-500 volts and within 2% at 10 volts.

HUM VOLTAGE
Within 10 Millivolts at any voltage or load within ratings.

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Detailed specifications will be forwarded upon request without obligation.

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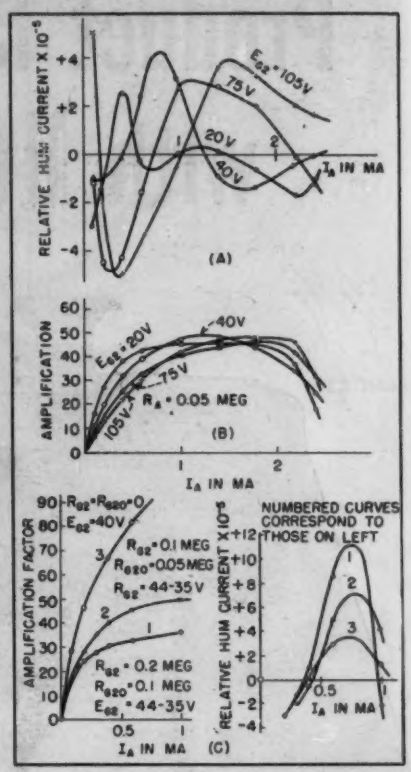

FIG. 3—Results obtained for sharp cutoff tube AF 7 (comparable to a 57)

it is necessary to take into consideration the change in gain produced by the change in grid bias (or plate current). This change is shown as a function of plate current, for use with Fig. 3A, in Fig. 3B. The effect of resistance in the screen circuit is shown by the two sets of curves in Fig. 3C; those to the left show change in gain, those to the right show relative hum, both as functions of plate current.

Comparing Fig. 2A and 2B it can be found that the equivalent hum amplification factor of the screen grid is 34 compared to 27 for the anode current amplification factor. This greater amplification factor for the hum is also evident from Fig. 3A. Figure 3C shows that, as the unbypassed screen resistance is increased, the hum increases and the gain decreases. The screen-grid voltage varies somewhat with plate current therefore the curves are not fully comparable. At plate currents below 0.4 ma the amplification factor is small so that the screen degeneration is negligible and the curves are therefore identical.

Figure 4 shows measurements on an AF 3; Fig. 4A shows the hum, Fig. 4B shows the gain. From Fig.

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Write for Bulletin No. 511 which gives further facts and figures.

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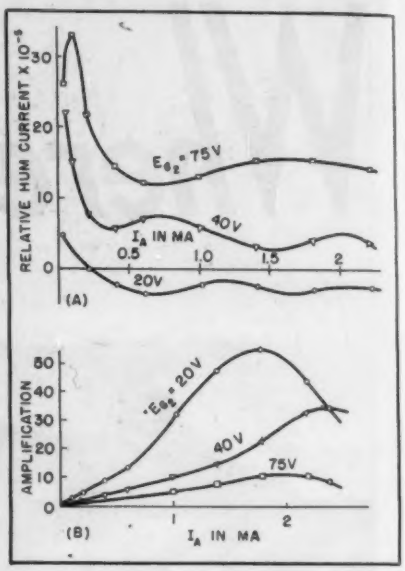

FIG. 4—Curves show change in hum and gain of variable-mu tube like a 58

4A one can infer that at some screen voltage between 20 and 40 volts there should be a hum curve having several zeros. From these measurements, as summarized in the introduction and as elaborated in these curves, it can be seen that the operating condition of a tube affects the relative hum current appearing in the plate circuit. Under special favorable conditions this hum current can be made to vary about zero magnitude.

In conclusion, I express my thanks to Mr. Nandor Szabo, chief of the Company Erdely and Szabo, for making the instruments, and to Mr. Henry Tabori for his help in the tests, which were completed in September 1944.

SURVEY OF NEW TECHNIQUES

STEREOSCOPIC SCREENS for motion picture or television projection before large audiences have been experimentally developed by E. G. Beard of the Philips Company in Sydney, Australia. In its simplest form the screen consists of a polished metal sheet engraved with over-lapping sets of concentric circular grooves of semicircular cross-section. The grooves act as concave mirrors that reflect the two images projected onto the screen to the observers at the correct angles. The

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principle can also be applied to transparent screens by using refracting circular elements instead of reflecting ones. Stereoscopic motion pictures have been successfully shown with the screen. Experiments will next be made to project stereoscopic television pictures in which the two views are transmitted with the interlacing, thus requiring no additional bandwidth.

NOISE has been put to good use by two physicists, Drs. J. V. Garrison and A. W. Dawson. By using the increase in thermal noise with temperature as an indication of temperature, they have devised a method of measurement that operates from absolute zero to about 5,000 F and is more accurate over this range than other means.

STATIC CHARGES can be dissipated as formed, thus preventing the possibility of abrupt discharges that produce interference, by placing minute amounts of polonium in the vicinity. Radiations from the rare radioactive element that are harmless to humans are, nevertheless, sufficient to ionize the surrounding air so that charges can be dissipated. Polonium can be plated easily onto other metals.

RESISTANCES from 10^6 to 10^{12} ohms, for use with phototubes, electrometers and other high-impedance devices, have been developed that consist of platinum evaporated on glass and sealed within a vacuum. Such resistors obey Ohm's law within about one percent from 0.1 to 300 volts, and are stable with time to within a few percent, unaffected by humidity, and are small, being about 2 inches long and 0.25 inch in diameter. A particularly interesting property of these resistors is that the magnitude of the noise produced by them equals that theoretically expected from the value of their resistance. Patented by D. Vodar, Laboratorie de Physique Enseignement, Sorbonne, Paris, the resistors are commercially produced by Etablissement Beaudouin (3 Rue Rataum, Paris).

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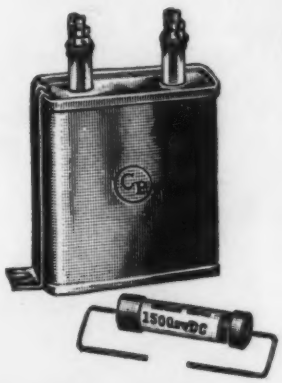
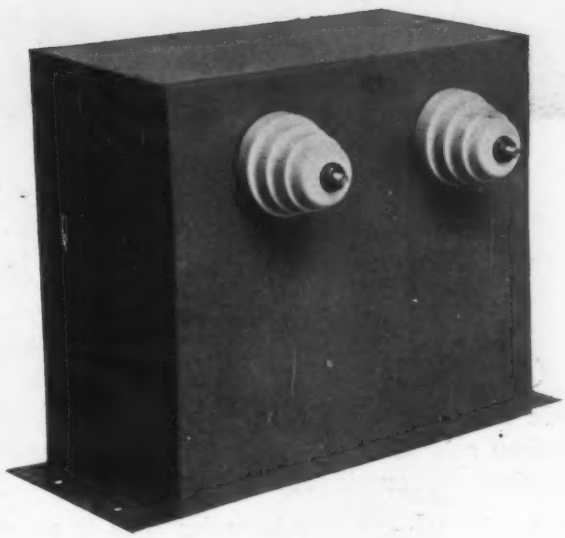


The dielectric combination in Type TS capacitors consists of "Teflon" film and "Silicone" fluid. Both materials are unusually temperature-stable and have extremely low dielectric losses. Properly engineered and processed, Type TS capacitors have remarkable characteristics.

A typical example is Type TSG103-3. This is an .01 mfd. 3000VDC capacitor in a Glassmike style container 29/32" OD x 2¼" long. The DC resistance is in excess of 100,000 megohms at 150°C. The dissipation factor at one megacycle is .0005 at 70°C and .001 at 150°C. At 60 cycles, the dissipation factor is as low as .0002 — .0003.

The temperature coefficient of Type TS is negative, 300—400 parts per million per degree Centigrade.

We recommend Type TS capacitors for ultra high temperature DC applications and for RF bypassing and coupling duty.



Type TS capacitors properly designed for pulse operation have many advantages over paper and mica capacitors. Type TS can operate at much higher ambient temperatures (150°C and up) but have much lower losses. The Type TS dielectric combination does not fatigue under pulse duty. PLASTICON networks are smaller and lighter.

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Fault Finder

We look for trouble in our coils — *before* they're built! Before a Wheeler coil is started, its component parts must be checked, tested, proved to be faultless.

The wire wound into Wheeler coils is no exception. It is closely inspected by experts — micrometer checks are made regularly to insure its uniformity. Only by following engineering practices proved over a long period of time can we be sure our coils will give the service and performance expected of them.

Wheeler coils — wound with Wheeler Magnet Wire — are rapidly becoming standard for the electrical industry. Investigate them today. They may be the answer to your electrical coil problems.

THE WHEELER INSULATED WIRE CO., INC.

SERVICE QUALITY WHEELER DEPENDABILITY

DIVISION OF THE SPERRY CORPORATION

1011 WASHINGTON AVENUE
BRIDGEPORT 4, CONNECTICUT

MAGNET WIRE • COILS • COMMUNICATIONS EQUIPMENT

UNIVERSITY OF MICHIGAN LIBRARIES

NEW PRODUCTS
(continued from p 130)

pressure of about 6 grams and cover a range from 40 cycles to over 10 kc.

Fidelity Pickup

SHURE BROTHERS, INC., 225 W. Huron St., Chicago 10, Ill. The 900MG crystal phonograph pickup for microgroove records provides high-fidelity reproduction. It tracks at 7 grams, has a needle force of

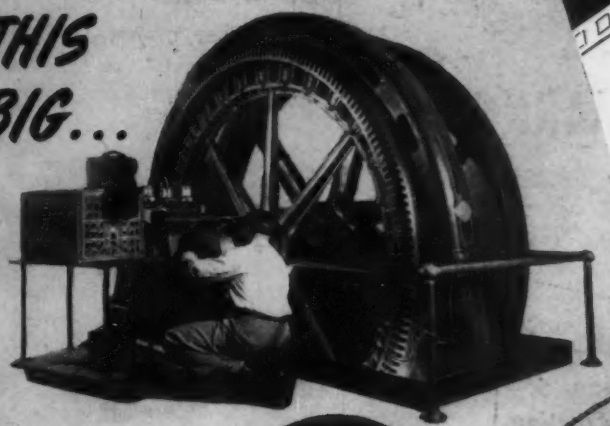
9 grams, uses an offset osmium-tipped needle with a 0.001-inch point radius and has an output of 1 volt.

High-Q Chokes

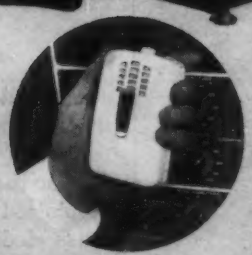
CHICAGO TRANSFORMER, 3501 W. Addison Blvd., Chicago, Ill. Designed specifically for use in dynamic noise suppressor circuits, the NSI-1 and NSI-2 reactors can be used in any tuned circuits requiring the given inductances. Induct-

To study the *simultaneous* characteristics of *any* device

THIS BIG...



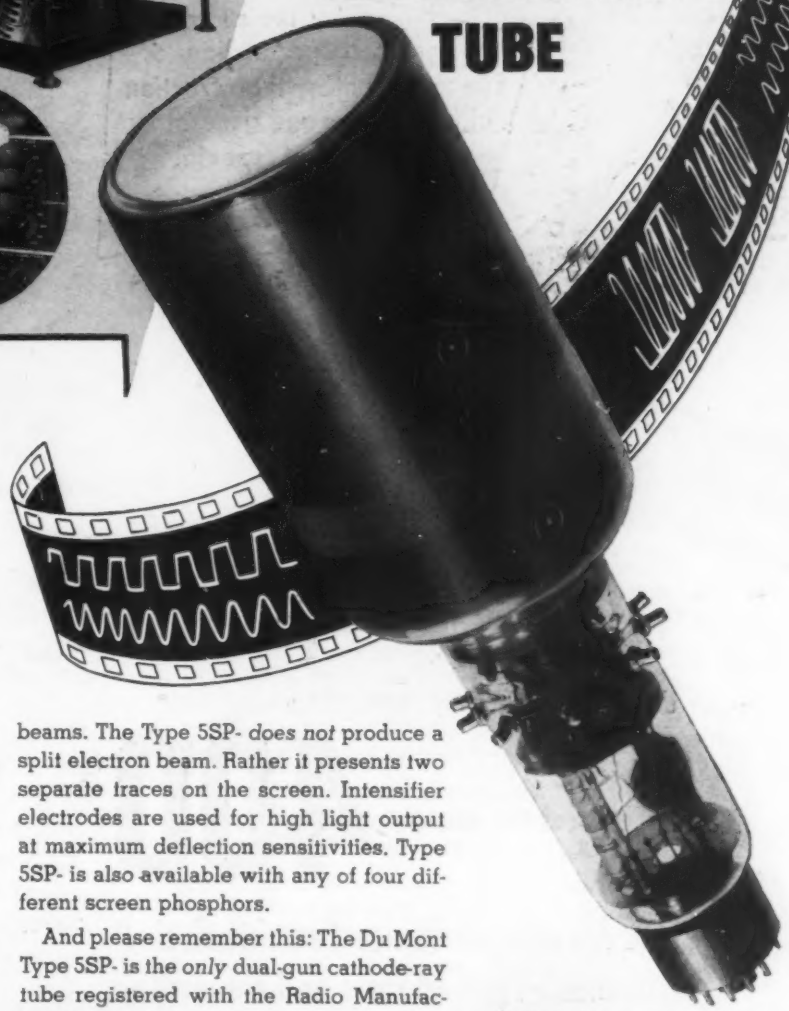
or this small...



...use the DU MONT Type 5 SP-

Dual-beam

CATHODE-RAY TUBE



Both the concomitant electrical and/or *mechanical* characteristics of a piece of equipment may be conveniently examined and recorded with a Du Mont Type 5SP- Dual-beam Cathode-ray Tube. Especially so if used with a Du Mont Type 279 Dual-beam Cathode-ray Oscillograph.

For example: You can compare speed and vibration, velocity and acceleration. You can observe transient voltage and current; the input and output signals of amplifiers; related phenomena on different sweep frequencies; or again the complete signal and an expanded portion thereof. And for ease of recording, there is also available the Du Mont Type 314 Oscillograph-record Camera.

Indeed, the Type 5SP- is an unique cathode-ray tube since it embodies *two complete and independent* electron guns and deflection plate assemblies for the production of two entirely separate electron beams. The Type 5SP- *does not* produce a split electron beam. Rather it presents two separate traces on the screen. Intensifier electrodes are used for high light output at maximum deflection sensitivities. Type 5SP- is also available with any of four different screen phosphors.

And please remember this: The Du Mont Type 5SP- is the *only* dual-gun cathode-ray tube registered with the Radio Manufacturers Association.

Details on request.

© ALLEN B. DU MONT LABORATORIES, INC.

DUMONT *for Oscillography*

ALLEN B. DU MONT LABORATORIES, INC., PASSAIC, N. J.
CABLE ADDRESS: ALBEEDU, NEW YORK, N. Y., U. S. A.

100,000 QUESTION MARKS

... were put to work!

by the successful design and production of Elinco instrument-type fractional h.p. motors and generators that met special needs.

Yes, every finished Elinco motor or generator was born of a question mark. There was a job to be done . . . could Elinco engineer and produce a special unit to do the job? The answer is in the over 100,000 special Elinco units, successfully designed to the most exacting specifications, and now serving in practically every type and branch of industry. Special design is our business . . . not low-cost, mass-production motors . . . but special high-precision instruments demanding the highest engineering ability, and exceptional manufacturing skill and care.

there are over **400**

Basic Models of Elinco Fractional H. P. Instrument-Type Motors and Generators

Units are produced to order, either by the design of a new model to meet your exact requirements, or by the adaptation of one of our over 300 basic units in order to meet your needs, either electrically or physically.

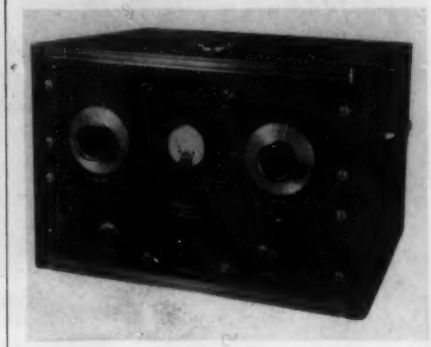
ELECTRIC INDICATOR CO.

PARKER AVENUE, STAMFORD, CONN.

ance values, 2.4 and 0.8 henrys respectively, are accurate within ±5 percent with up to 15 ma d-c. Units have a minimum Q of 20.

Servo Tester

SERVO CORP. OF AMERICA, 2020 Jericho Turnpike, New Hyde Park, N. Y. The Servoscope is the first of



a line of design instrument aids for the servomechanisms engineer. It furnishes continuous performance data so that frequency response can be plotted and transient characteristics deduced in a few minutes. Rapid measurements are furnished of frequency-versus-amplitude attenuation and phase shift.

Audio-Frequency Meter

GENERAL RADIO CO., 275 Massachusetts Ave., Cambridge 39, Mass. Discontinued during the war years,

type 1141-A audio-frequency meter is again available. Using a null method, accuracy of the bridge is 0.5 percent. Because it uses a Wien bridge circuit, the instrument can be used as an adjustable-frequency filter over its range from 20 to 20,000 cycles.

Tripod Dolly

RADIO CORP. OF AMERICA, Camden, N. J. Type MI-26042 portable chrome-finished dolly may be used

THEY BOTH HAVE IT

The EXTRA SOMETHING that spells TOP PERFORMANCE

Seletron
SELENIUM RECTIFIERS

Built on Aluminum

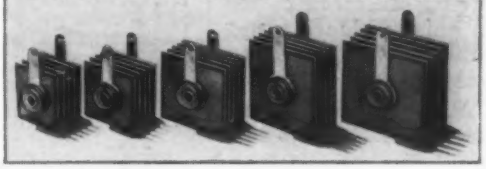
THE football star who eludes the players of the rival team and sends the pigskins hurtling down the field to a goal has "the extra something that spells top performance."

For outstanding service in every rectifier application specify Seletron Selenium Rectifiers. They have the "extra something" that spells top performance.

From the large power stacks to the miniature units for radio and television, Seletron uniformity and precision methods of manufacture, insures user satisfaction. Efficient—dependable, durable under the severest service conditions.

Furnished in a wide variety of voltages and currents to meet the individual requirements.

MINIATURE SELETRON RECTIFIERS



SPECIFY SELETRON
MINIATURE SELENIUM RECTIFIERS
FOR RADIO AND TELEVISION APPLICATIONS

The complete family of miniature Seletron Rectifiers is designed for use on a nominal 115 A-C line, to provide direct current for radio, television sets, amplifiers, and other low power applications. Instant starting, small size, long life and simplicity of installation are a few of many features of the Seletron Family.

CODE NUMBER	5L1	5M1	5P1	5R1	5Q1
Current Rating	75 ma.	100 ma.	150 ma.	200 ma.	250 ma.
Plate Height	1"	1"	$1\frac{3}{16}$"	1½"	1½"
Plate Width	⅞"	1"	$1\frac{3}{16}$"	1¼"	1½"

Write today for catalog. Address Dept. ES-11

SELETRON DIVISION
RADIO RECEPTOR COMPANY, Inc.
Since 1922 in Radio and Electronics
251 WEST 19TH STREET. NEW YORK 11, N. Y.

Laboratory and Research Instruments

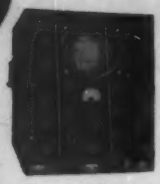
ENGINEERED FOR ENGINEERS

SWEEP CALIBRATOR Model GL-22

This versatile source of timing markers provides these requisites for accurate time and frequency measurements with an oscilloscope:

Positive and negative markers at 0.1, 0.5, 1.0, 10, and 100 microseconds ● Marker amplitude variable to 50 volts ● Gate having variable width and amplitude for blanking or timing ● Trigger generator with positive and negative outputs.

Further details in Bulletin **MC-811**



OSCILLOSYNCHROSCOPE
Model OL-15B

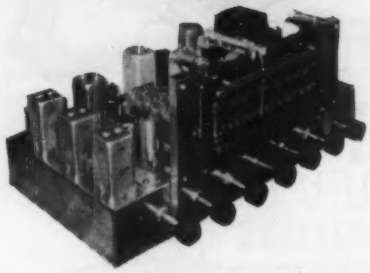
Provides a variety of time bases, triggers, phasing and delay circuits, and extended-range amplifiers in combination with all standard oscilloscope functions.

Extended-range amplifiers: vertical, flat within 3 db 5 cycles to 6 megacycles; horizontal, flat within 1 db 5 cycles to 1 megacycle ● High sensitivity: vertical, 0.05 RMS volts per inch; horizontal 0.1 RMS volts per inch ● Single-sweep-triggered time base permits observation of transients or irregularly recurring phenomena ● Variable delay circuit usable with external or internal trigger or separate from 'scope ● Sawtooth sweep range covers 5 cycles to 500 kilocycles per second ● 4,000-volt acceleration gives superior intensity and definition. Request Bulletin **MO-811**

Enjoy High-fidelity

RADIO RECEPTION WITH THE

Browning FM or FM-AM *Tuner*



This is the new Model RJ-20 FM-AM Tuner . . . designed for high-fidelity reception on both FM and AM, and built to meet your highest performance requirements. Its features include:

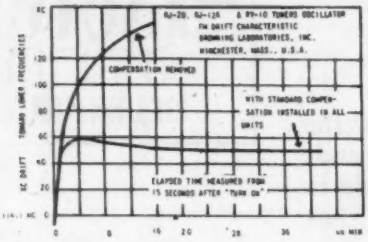
- **Armstrong FM circuit for maximum noise reduction and full frequency response to 15,000 cycles.**
- **Separate RF and IF systems for FM and AM . . . no coil switching.**
- **Variable bandwidth IF gives AM bandwidths from 9 kc. to 4 kc.**
- **Two-stage audio system allows 20 db. boost in bass or treble range.**
- **New 6AL7 tuning eye for precise tuning on strong or weak FM stations.**
- **Self-contained power supply.**

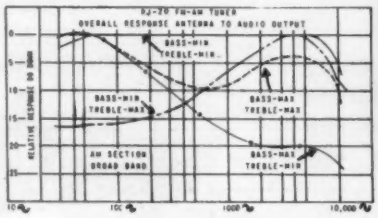
See, hear, and handle this new Browning Tuner . . . and enjoy new satisfaction in your radio and music reproduction.

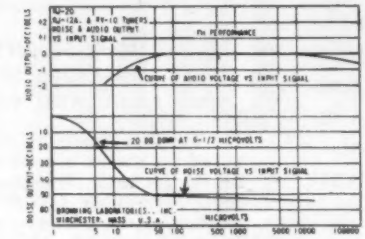
Write today for Data Sheet MT-811

HERE'S PERFORMANCE to satisfy the man who knows radio . . . provable by both instrument and listening tests.

CHECK THESE CURVES and you'll see why Browning Tuners are chosen by those who insist upon the best.


RJ-20, RJ-12A & RV-10 TUNERS OSCILLATOR
FM DRIFT CHARACTERISTIC
BROWNING LABORATORIES, INC.
WINCHESTER, MASS., U.S.A.
COMPENSATION REMOVED
WITH STANDARD COMPENSATION INSTALLED IN ALL UNITS
ELAPSED TIME MEASURED FROM 15 SECONDS AFTER "TURN ON"
AC DRIFT TOWARD LOWER FREQUENCIES
MINUTES





To feed a separate high-fidelity audio system, use the Browning RJ-12A for FM/AM or the Browning RV-10 for straight FM. They're all "tops" in the high-fidelity field.

BROWNING
LABORATORIES, INC.
WINCHESTER, MASS.

ENGINEERED FOR ENGINEERS

both for field-type and studio television tripods. It can be locked in a fixed position by means of spring-loaded stop-feet.

Cabinet Racks

ECLIPSE MFG. CO. INC., 294 East 137th St., New York 54, N. Y. A new line of six cabinet racks is available with panel heights rang-

ing from 8¾ to 35 inches. Mounting holes are tapped for 10–32 screws with standard or amateur hole spacing.

Mobile Equipment

COMMUNICATIONS CO., INC., 300 Greco Ave., Coral Gables, Florida. Model 275-C radiotelephone equipment is designed for mobile applications in the emergency services operating in the 152 to 162-mc f-m

One of a series *of messages to help you increase your understanding of business paper advertising, and its effect on your job.*

You know more about advertising than you think !

IF YOU UNDERSTAND the basic principles of mass production —

If you're on familiar ground when it comes to time-motion studies, obsolescence curves, and assembly-line techniques —

If you regard every operation in your plant as a challenge to further reduce your manufacturing cost-per-unit —

Then you know a lot more about advertising than you think. Yes, *advertising!*

For basically, advertising is the application of assembly-line techniques to the *manufacture of a sale.* And how are sales manufactured? Like any other commodity, by sequence of "processing operations." In this case they include —

1. **Seeking out prospects**
2. **Arousing their interest**
3. **Creating a preference for your product**
4. **Making a specific proposal**
5. **Closing the order**

Couldn't your salesmen handle this entire sequence? Certainly — if you had *enough* salesmen, and weren't concerned about the cost. But no salesman should *have* to spend his valuable time on missionary work. Not when those first three steps can be *mechanized* for him — not when they can be handled so much more economically — through the efficient use of business-paper advertising.

Why *business* papers? Because nowhere does your advertising work more efficiently than in the business publications which reach your best prospects. Nowhere else can "mechanized selling" contribute so much toward reducing the cost of manufacturing a sale!

ELECTRONICS

is a member of The Associated Business Papers, who have published an interesting folder entitled, "10 ways to measure advertising effectiveness." We'll be glad to send you a copy. And if you'd like reprints of this advertisement (or the entire series) to pass along to others in your organization, just say the word.

CURRENT CONVERSION

ATR STANDARD AND HEAVY DUTY INVERTERS

For Inverting D. C. to A. C. . . .

Specially Designed for operating A. C. Radios, Television Sets, Amplifiers, Address Systems, and Radio Test Equipment from D. C. Voltages in Vehicles, Ships, Trains, Planes and in D.C. Districts.

New Models

ATR

AUTO RADIO VIBRATORS

A Complete Line of Vibrators . . .

Designed for Use in Standard Vibrator-Operated Auto Radio Receivers. Built with Precision Construction, *featuring Ceramic Stack Spacers* for Longer Lasting Life.

New 36 page VIBRATOR GUIDE FREE

New Models

ATR

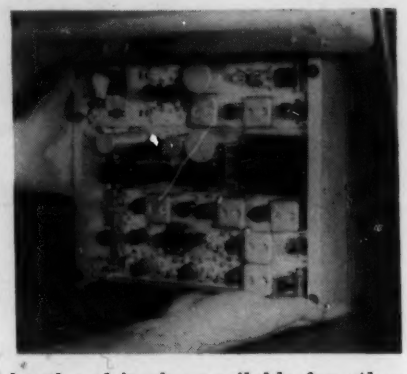
"A" BATTERY ELIMINATORS

For DEMONSTRATING AND TESTING AUTO RADIOS

New Models . . . Designed for Testing D. C. Electrical Apparatus on Regular A. C. Lines. Equipped with Full-Wave Dry Disc Type Rectifier, Assuring Noise-less, Interference-Free Operation and Extreme Long Life and Reliability.

✓ NEW MODELS
✓ NEW DESIGNS
✓ NEW LITERATURE
See your jobber or write factory

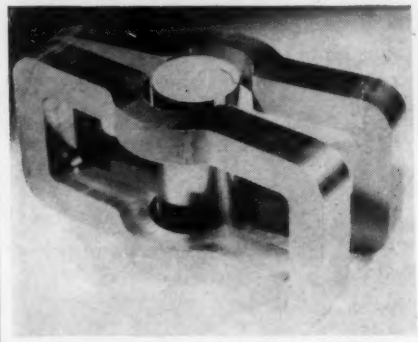
AMERICAN TELEVISION & RADIO CO.
Quality Products Since 1931
SAINT PAUL 1, MINNESOTA—U.S.A.



band and is also available for other f-m services operating above 30 mc. The unit weighs 20 pounds, has a transmitter power output of 8 to 10 watts, a battery drain of 6 amperes standby, and 13 amperes when transmitting. Audio output from receiver is over 1 watt.

Deflection Cores

HENRY L. CROWLEY & CO., INC., 1 Central Ave., West Orange, N. J. A two-piece frame and center slug



assembly of powdered iron is being made for television receiver deflection transformers. Effective a-c permeabilities in the order of 40 to 230 are attainable. Hum noise is low as compared with that produced in laminated core structures.

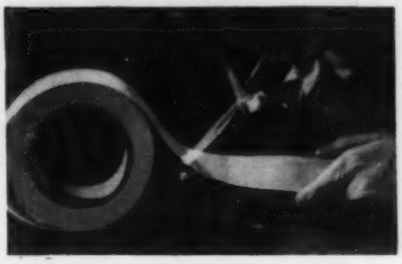
Bridge Amplifier

RUGE-DE FOREST, 76 Massachusetts Ave., Cambridge, Mass. The new deflection-type amplifier is designed for use with resistance

bridges ranging in impedance from 100 to 500 ohms and having a full-scale output as small as 25 microvolts per volt of input to the bridge, or as large as 5 millivolts per volt. Output is 18 volts across an external 1500-ohm load with a linearity of 0.5 percent. Frequency response is flat to ±2 percent from 0 to 50 cycles when working into a resistive load.

Electrical Insulation

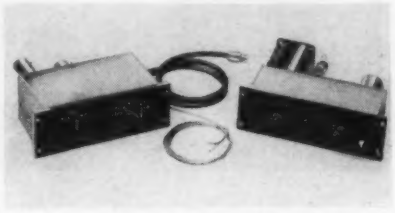
JOHNS-MANVILLE, 22 E 40th St., New York 16, N. Y. An asbestos-base, completely inorganic electrical



insulation, Quinterra was designed for use where high temperatures are encountered since it retains its dielectric strength of over 250 volts per mil. It has already been used as wire insulation in transformers.

Equalizer

BROCINER ELECTRONICS LABORATORY, 1546 Second Ave., New York 28, N. Y. Model A65 amplifier and



companion model P6-300 d-c power supply provide a means of compensating magnetic phonograph pickups to various recording characteristics. Turnover frequencies of 300, 500, and 800 cycles are accommodated.

F-M Transceiver

DOOLITTLE RADIO, INC., 7421 South Loomis Blvd., Chicago 36, Ill. The PJZ-1 portable f-m transmitter and receiver with quarterwave telescopic antenna is designed for operation on a single frequency in the

An Important Statement

by

MYCALEX

CORPORATION OF AMERICA

An explanation of the properties and advantages of Mycalex (glass bonded mica) 410, Mycalex 400, and Mycalex K are given on the opposite page.

Your attention is also called to the Mycalex 410 advertisement which appeared on pages 54 and 55 of the October 1948 issue of Electronics.

Constant research, improved technics, advances in the art, new, modern plant expansion, improved engineering, more efficient manufacturing equipment—now permit us to make available in increased quantities—Mycalex 410—molded—*at prices comparable* to other less efficient molded insulations.

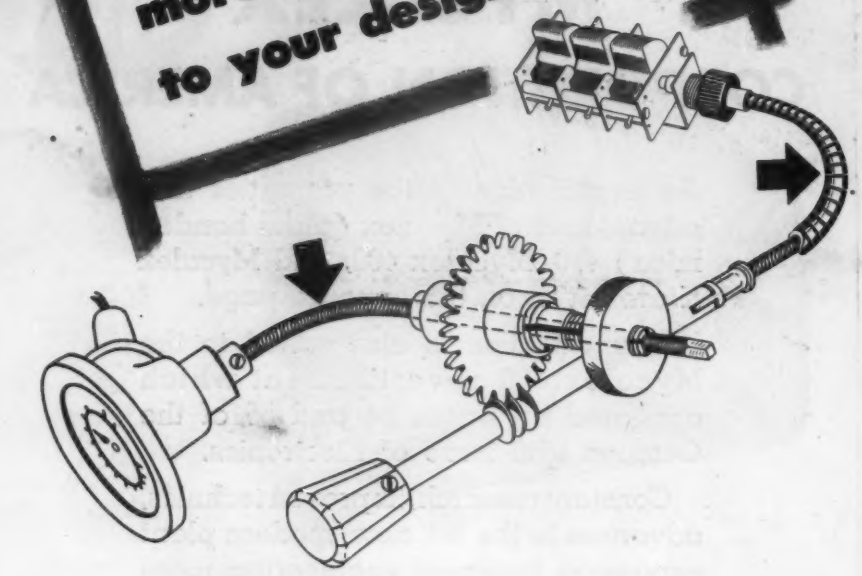
MYCALEX 410 is now priced to meet rigid economy requirements

Any interest evidenced on your part in Mycalex products and services—will receive the prompt, courteous and intelligent attention of a competent Mycalex sales engineer. He will receive the fullest backing and cooperation from other factory executives—to serve you promptly—with a quality product and at an economical and fair price.

SINCE 1919 MYCALEX THE INSULATOR

Simplify WITH S.S.WHITE FLEXIBLE SHAFTS

Make controlled parts more ADAPTABLE to your designs



Adaptability is a prime advantage you gain by using S.S.White flexible shafts to couple variable elements to their control knobs or dials.

The example above shows why. The flexible shaft coupling permits you to position both the condenser and its control knob independently of each other. Likewise, the flexible shaft that transmits the movement of the tuning control shaft through a worm gear to the indicating dial makes it possible to place the dial where desired.

This *adaptability* of parts provided by S.S.White flexible shafts greatly simplifies the problem of satisfying such design requirements as circuit efficiency, easy assembly, wiring and servicing.

S.S.White remote control flexible shafts come in a wide range of sizes and characteristics and can be supplied in any required length. Specially designed for remote control they are positive, sensitive and jump-free in operation.

GET DETAILS IN THIS FLEXIBLE SHAFT HANDBOOK

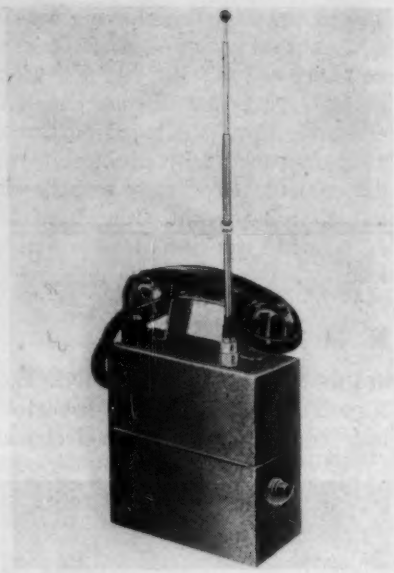
You can get a free copy of this informative 260-page book on flexible shaft application and selection by writing to us on your business letterhead and mentioning your position.

S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO. DEPT. E 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
MOLDED RESISTORS • PLASTIC SPECIALTIES • CONTRACT PLASTICS MOLDING

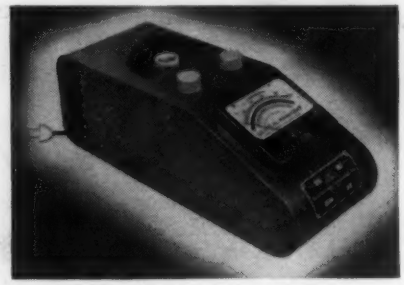
One of America's AAAA Industrial Enterprises



30 to 44-mc band. Power output of the transmitter is ½ watt, obtained from two 2-volt storage batteries. The receiver has a 1½-μv sensitivity for 20-db silencing, and selectivity is 85 db down at 100 kc and 40 db down at 40 kc.

Colorimeter

BROCINER-MASS INSTRUMENTS, INC., 1546 Second Ave., New York 28, N. Y. The Clinical Analyzer is a



photoelectric colorimeter calibrated for 60 clinical determinations. The instrument uses test tubes 17 and 11 mm in diameter. Five filters in a revolving disc permit quick selection.

Klystron Oscillators

RADIO CORP. OF AMERICA, Harrison, N. J., announces the 2K26 (illustrated) and 2K56 klystron oscillators of the single-resonator, reflex type intended primarily for use as local oscillators in microwave receivers. The 2K26 is designed for operation in the 6,250 to 7,060-mc

Speaker News
MODERN NEW MAGNAVOX FACTORY IS LOUD SPEAKER HEADQUARTERS FOR THE MANUFACTURING TRADE
Specializes In Speakers For Every Type Installation
The Magnavox speaker factory at Paducah, Kentucky, is less than a year old, yet it is recognized throughout the industry as the outstanding speaker plant in America today . . .
The Magnavox Company of Kentucky, at Paducah

NOW Magnavox produces over 100 different speaker models exclusively for the manufacturing trade. From start to finish they are researched, designed and produced by engineers whose sole business is the making of better loud speakers . . . whose complete plant facilities are constructed specially for the quickest, most efficient manufacture of quality loud speakers!

The modern 2½-acre Magnavox Paducah factory is a model of engineering achievement. Everything from the building itself to the equipment and method of line assembly used is new and different. And the innovations measure up! World-famous Magnavox speakers now are coming off the line at a greatly accelerated pace.

All the skill and experience Magnavox has amassed in thirty-three years of service to the radio industry combine with a complete line of quality speakers to make this modern new plant loud speaker headquarters! Write for catalog today.

The Magnavox Company, Sales and Engineering Offices, Components Division, Ft. Wayne 4, Indiana.

Magnavox is the oldest and largest producer of quality loud speakers

Magnavox

has served the radio industry for over 33 years

SPEAKERS · CAPACITORS · SOLENOIDS · ELECTRONIC EQUIPMENT

TRIPLE INDEMNITY WITH

ALPHA TRI-CORE *Rosin-filled* SOLDER

faster · more economical · more efficient

Alpha Tri-Core rosin-filled solder—with 3 cores instead of 1—gives you three times the "performance insurance" you get from ordinary solder. The simple facts are: You get more for your money with Alpha Tri-Core rosin-filled solder — more speed! More operations per pound! More operations per hour! In addition, Tri-Core permits the use of lower-tin-content alloys *with superior soldering results* to that obtained from ordinary solders with 5-15% more tin. Can you—can any manufacturer—afford to overlook such outright savings these days? Write for samples or trial order and put Alpha through your own tests in your own shop. It is the accepted solder by over 70% of electronic equipment manufacturers.

MORE FOR YOUR MONEY WITH ALPHA *TRI-CORE* ROSIN-FILLED SOLDER

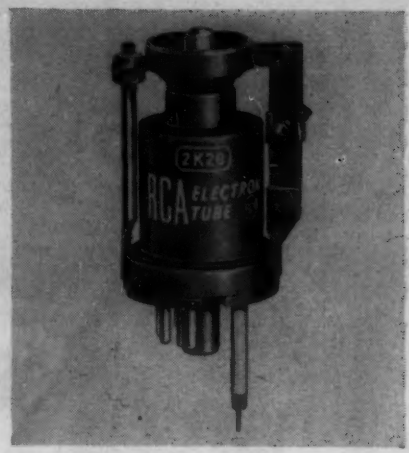
SOLDER SPECIALISTS FOR OVER 58 YEARS

- 3 cores of flux instead of 1—at no extra cost!
- Even distribution of flux throughout . . . no fluxless areas!
- 22% more joints per pound of solder!
- 25% more joints per hour of soldering time!
- No high-resistance joints! No inspection rejects! No returns!
- 99.9% pure, water-white rosin used exclusively!
- No toxic fumes! Preferred by solderers everywhere!
- Absolutely non-corrosive; non-hydroscopic flux residue is glass-like in hardness and non-conductive!

Alpha

other ALPHA PRODUCTS include: TRI-CORE "ENERGIZED" ROSIN-FILLED SOLDER; TRI-CORE "LEAK-PRUF" ACID-FILLED SOLDER, SOLID SOLDER WIRE; PREFORMS (rosin and acid-filled); BAR SOLDER, ANODES AND FOIL.

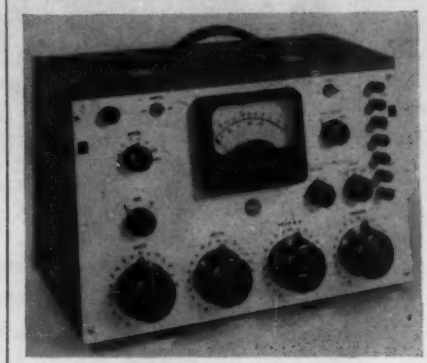
ALPHA METALS, INC., 371 HUDSON AVENUE, BROOKLYN 1, NEW YORK



range, and the 2K56 in the range from 3,840 to 4,460 mc. Both have a useful power output in the order of 100 milliwatts.

Remote Amplifier

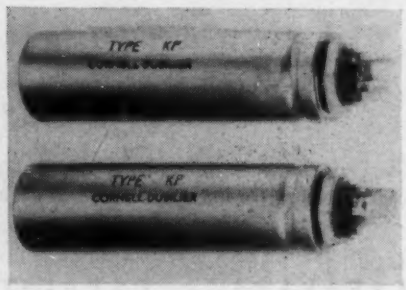
RADIO CORP. OF AMERICA, Camden, N. J., has announced a lightweight, portable remote amplifier designed



to provide high-fidelity audio pick-up for a-m and f-m broadcasts. The 3-channel amplifier, type BN-2A, has built-in power supply for use with standard 115-volt, 60-cycle outlets, but may also be battery-operated. Each channel offers an overall gain of 92.5 db.

Electrolytic Capacitors

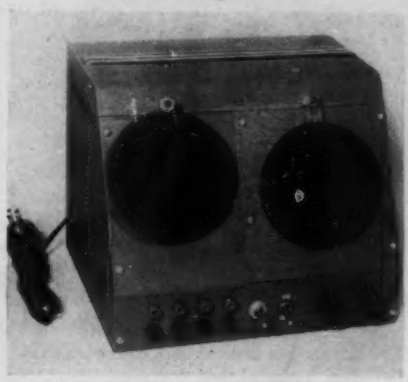
CORNELL-DUBILIER ELECTRIC CORP., South Plainfield, N. J. Type KP



electrolytic capacitors designed for electronic and communications equipment are available in two and three-lug terminal assemblies. Two-lug units can be had from 15 microfarads at 100 working volts to 80 microfarads at 450 working volts; three-lug terminals are suitable for either dual or triple capacitance units. Write for bulletin 123.

T-F Analyzer

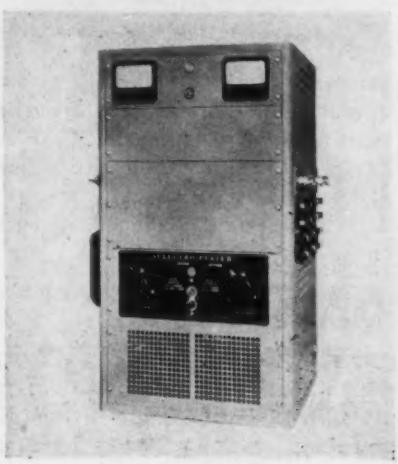
FAIRCHILD CAMERA AND INSTRUMENT CORP., 88-06 Van Wyck Blvd., Jamaica 1, N. Y. The transfer func-

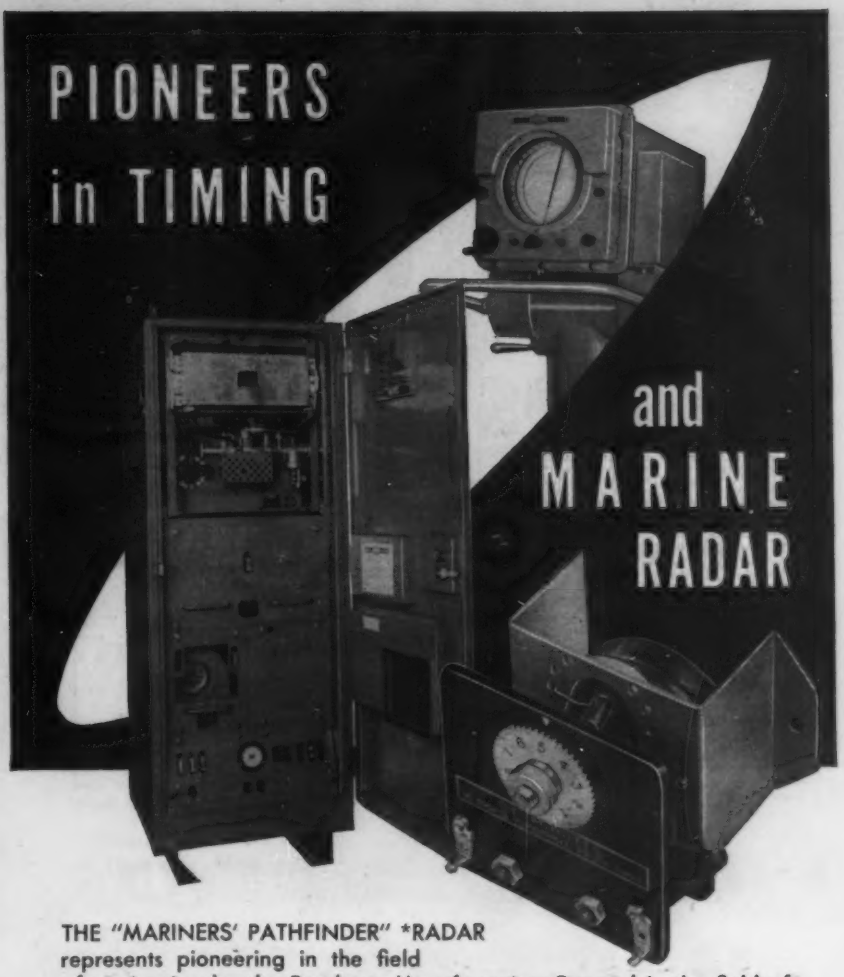


tion analyzer has been designed for measuring the performance characteristics of servo systems. By means of the equipment, amplitude and phase of servos using signal frequencies between 50 and 800 cycles can be checked. It can also be modified for use with d-c systems.

Laboratory Power Supply

W. GREEN ELECTRIC CO., INC., 130 Cedar St., New York 6, N. Y. The MR1 Multi-Rectifier power supply was produced to meet the need for a high-amperage laboratory unit. It





THE "MARINERS' PATHFINDER" *RADAR represents pioneering in the field of navigation by the Raytheon Manufacturing Co. and in the field of timing by Haydon Manufacturing. The development of equipment components enabling today's ships to sail safely and on schedule in all weather is typical of Haydon's pioneering in the science of timing. Knowing that any equipment is only as good as its components, Raytheon relies on the quality of Haydon timers for dependable radar operation. In one model, a 5901 series time delay relay protects a magnetron tube by providing a 3 minute interval for tube warm-up prior to application of plate voltage. In another a Haydon timer provides a 5 second delay to allow a motor generator to attain operating speed. A third delays operation of rectifier tubes 45 seconds. In each instance engineering by Haydon and Raytheon is coupled to insure dependable operation.

For thoroughly reliable timing devices, take time to talk time with Haydon. See the Haydon insert in Sweet's File for Product Designers, or write for your own copy of the complete Engineering Catalog. An experienced field representative will be pleased to discuss your requirements and demonstrate Haydon timing at your desk.

* "Mariners' Pathfinder" is the trademark of Raytheon Manufacturing Co., denoting its commercial search radar.

WRITE 2411 ELM STREET, TORRINGTON, CONNECTICUT

HAYDON

MANUFACTURING COMPANY, INC.

TORRINGTON CONNECTICUT

HARNESS TIME TO YOUR PRODUCTS

SUBSIDIARY OF GENERAL TIME INSTRUMENTS CORPORATION

Only AIR EXPRESS gives you all these advantages

A combination you don't get with other air-shipping methods

1. Special pick-up and delivery *at no extra cost.* Your shipments are picked up promptly when you call; fast delivery to consignee's door.

2. *You get a receipt for every shipment,* and delivery is proved by signature of consignee. One-carrier responsibility. Complete security.

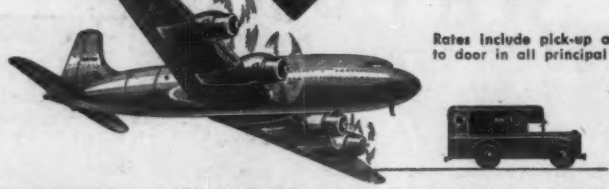
3. Assured protection, too—valuation coverage up to $50 without extra charge; 10 cents for each additional $100 or fraction thereof.

These advantages, plus 21 others, make Air Express the best and fastest way to ship. Your shipments go on every flight of the Scheduled Airlines—repair parts, equipment, finished items *keep moving* to where they're needed. Reach any U.S. point in hours. Phone local Air Express Division, Railway Express Agency, for fast shipping action. Specify "Air Express" on orders for quickest delivery.

FACTS on low Air Express rates

22 lbs. machine parts goes 700 miles for $4.73.
10 lbs. printed matter goes 1000 miles for $3.31.
30-lb. carton of new fashions goes 500 miles for $4.61.
Same day delivery in all these cases if you *ship early.*

SPECIFY AIR EXPRESS
GETS THERE FIRST



Rates include pick-up and delivery door to door in all principal towns and cities

AIR EXPRESS, A SERVICE OF RAILWAY EXPRESS AGENCY AND THE
SCHEDULED AIRLINES OF THE U.S.

is designed for operation from 220 or 440 volt, three-phase a-c, and has a flexible d-c output. Output voltage ripple content is about 5 percent.

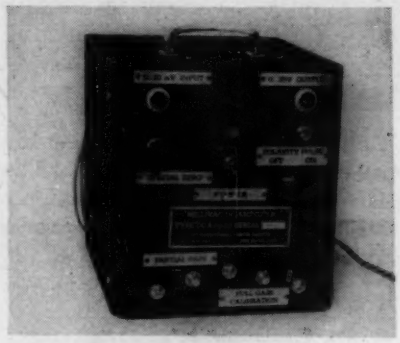
Studio-Type Ribbon Mike

AMPERITE CO., INC., 561 Broadway, New York 12, N. Y. Frequency range of the new studio ribbon mi-

crophone models R80L & R80H is 40 to 14,000 cps; output is −56 db; harmonic distortion, less than 1 percent; discrimination with angle is 60 to 10,000 cycles. The unit is available in 200 ohms output, also in high impedance.

D-C Amplifier

MILLIVAC INSTRUMENTS, Box 3027, New Haven, Conn. Model DCA-1025 d-c amplifier has a 0 to 10 millivolt d-c input and 25 v, 1-milli-

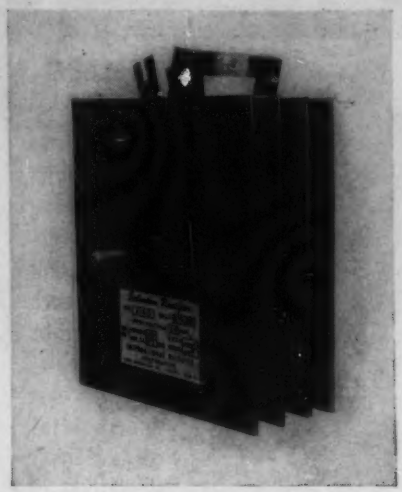


ampere or 5-volt 3-milliampere d-c output. Its applications are the same as those of the model MV-17A device but it can be used with either delicate or coarse output meters. Adjustable gain is included. A brochure gives further details.

Selenium Cell

INTERNATIONAL RECTIFIER CORP., 6809 South Victoria Ave., Los Angeles 43, Calif. The new type H selenium cells illustrated have a

maximum reverse voltage of 24 v rms with current ratings from 6 to 20 amperes depending upon the type of connection. Forward drop is about 1 volt. A brochure is available.

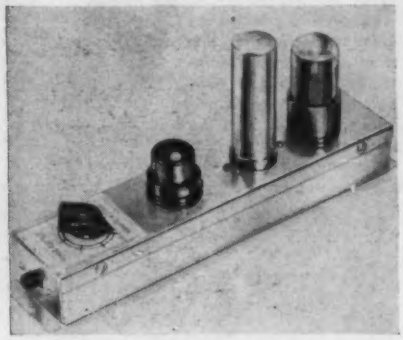


Miniature Controls

DAVEN CO., 191 Central Ave., Newark, N. J. A new line of attenuators with decreased dimensions is now in production. They are designed for use in equipment in which mounting space is limited and have the same mechanical and electrical construction as former units.

Speech Clipper

ELECTRO-VOICE, INC., Buchanan, Mich. Model 1000 Speech Clipper

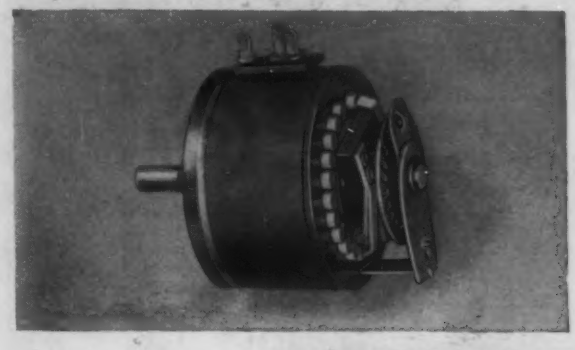


is a peak limiting preamplifier that clips the tops and bottoms from speech frequencies which rise above a preset amplitude, to provide higher articulation for communication services. Frequency response of the unit is from 200 to 3,000 cycles. Clipping is from 3 to 20 db.

Fidelity Speaker

RACON ELECTRIC CO., INC., 52 East 19th St., New York, N. Y. The Cel-

Shallcross
ATTENUATORS



BRIDGED 'T' ATTENUATOR
Type 410-4B1

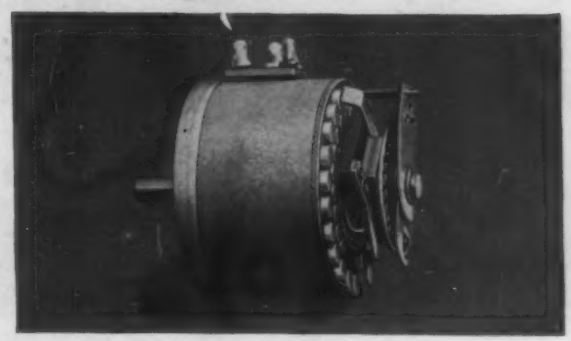
10 steps, 4 db/step. Linear attenuation with detent. 2⅛" diameter, 2⅛" depth.

$11.50
LIST PRICE

BRIDGED 'T'. ATTENUATOR
Type 420-2B2

20 steps, 2 db/step. Linear attenuation with off position and detent. 2⅛" diameter, 2⅛" depth.

$16.00
LIST PRICE



POTENTIOMETER
Type C720-2A3

20 steps, 2 db/step, tapered on last three steps to off, composition resistors. 1¾" diameter, 1¾" depth.

$8.00
LIST PRICE

These Shallcross Features Mean Better Performance—Better Value!

Off position attenuation well in excess of 100 db.

25% to 50% fewer soldered joints.

Noise level ratings that are factual. (130 db. or more below zero level.)

Non-inductive Shallcross precision resistors used throughout assure flat attenuation to and beyond 30 kc.

Types and sizes engineered for all needs. Attenuation accuracies of 1%, Resistor accuracies of 0.1%, on special order.

SHALLCROSS ATTENUATORS

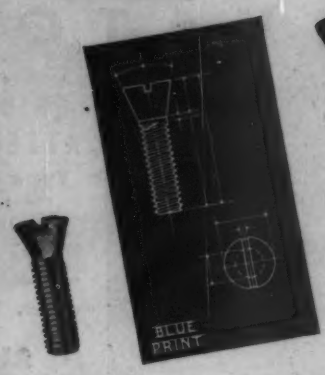
Shallcross variable attenuators have proved their remarkable quietness and serviceability in dozens of applications for leading users in all parts of the world. Such important details as the use of spring-temper silver alloy wiper arms, silver alloy collector rings and contacts, non-inductive precision resistors, and sturdy, substantial mounting plates have made possible the high standard of performance attributed to Shallcross.

Standard types include ladder and bridged T mixer controls, bridged T and straight T master gain controls and V.U. meter multipliers, wirewound and composition potentiometers for grid control. Cueing attenuators, and fixed pads, both composition and wirewound, in all circuit configurations are also available.

Write for Catalog and Attenuator Specification Sheet

SHALLCROSS MANUFACTURING COMPANY
Department E-118, Collingdale, Pa.

ANOTHER SPECIAL BY PROGRESSIVE



ACTUAL SIZE

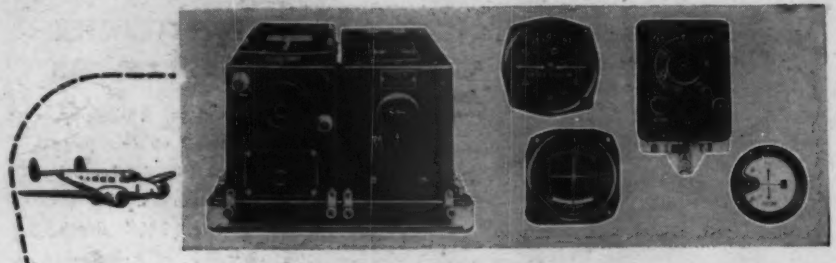
ENLARGED FOR DETAIL

CATALOG SHOWS DOZENS MORE

Special heads, threads and finishes on any metal or alloy adapted to cold upset. Weekly output: 25,000,000 pieces. Many specials, suggesting production savings for you, illustrated in latest catalog. Includes weights per 1M standard pieces, dec. equivs. of fractions, other purchasing and engineering helps. Write for Catalog 19.

The PROGRESSIVE MFG. CO.

50 NORWOOD ST. TORRINGTON, CONN.



The Magic of **VHF**

Airborne Equipment for:

OMNI-DIRECTIONAL RANGES
RUNWAY LOCALIZERS
VISUAL-AURAL RANGES
SIMULTANEOUS VOICE
GCA VOICE RECEPTION

The Type 15A VHF Navigational Receiving Equipment (illustrated) provides for reception on the new Omni-Directional Ranges as well as operation on both types of VHF Runway Localizers, and the VHF Visual-Aural Airways Ranges. Simultaneous voice feature is included on these ranges. The *tunable* A.R.C. Receiver permits selection of any VHF aircraft frequency.

The A.R.C. Type 17 or A.R.C. Type 18 is the companion communication equipment normally associated with the Type 15A. The Type 17 VHF Communication Equipment adds independent two-way VHF communication facilities. The Type 18 adds VHF Transmitting Equipment only. All Type 17 and 18 units are type-certificated by the CAA.

The dependability and performance of these VHF Communication and Navigation Systems spells increased safety in flight. Specify A.R.C. for your next installation.

ARC Aircraft Radio Corporation

BOONTON, NEW JERSEY

DEPENDABLE ELECTRONIC EQUIPMENT SINCE 1928

American Beauty

ELECTRIC SOLDERING IRONS

are sturdily built for the hard usage of industrial service. Have plug type tips and are constructed on the unit system with each vital part, such as heating element, easily removable and replaceable. In 5 sizes, from 50 watts to 550 watts.

TEMPERATURE REGULATING STAND

This is a thermostatically controlled device for the regulation of the temperature of an electric soldering iron. When placed on and connected to this stand, iron may be maintained at working temperature or through adjustment on bottom of stand at low or warm temperatures.

Write for Catalog Sheets 110-1

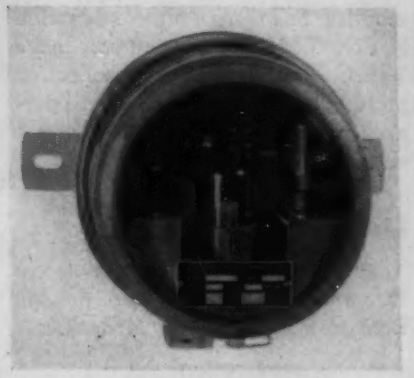
AMERICAN ELECTRICAL HEATER COMPANY

DETROIT 2, MICH., U. S. A.

lular Grand has a new type cellular horn with horizontal distribution angle of 120 degrees and vertical distribution of 60 degrees. A resistive-capacitive filter network is included. Frequency range is 50 to 12,000 cycles.

Street Lighting Control

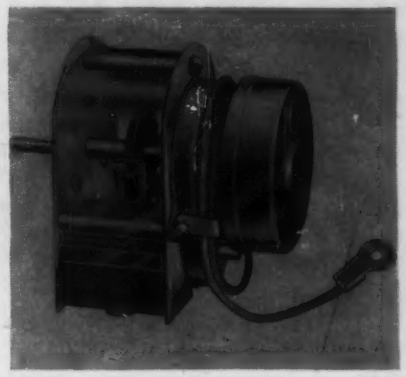
FISHER-PIERCE CO., INC., Boston 21, Mass. announces the series 63300



photoelectric street lighting control with a capacity of 3,000 watts of incandescent lamp load. Models are available for both 120 and 230 volts, 50-60 cycles. Standard turn-on adjustment is 0.5 foot-candle with turn-off at 1.25 foot-candles.

Interval Timer

HAYDON MFG. CO., INC., Torrington, Conn. A new multipurpose interval



timer is now available in the 8006 series. Several different models in the series are used for varying applications such as multiple sequence switching.

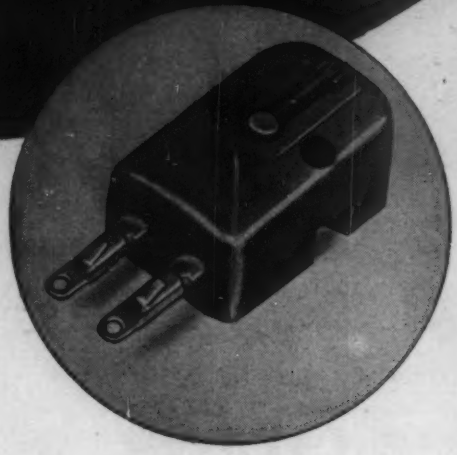
Portable Picture Monitor

POLARAD ELECTRONICS CO., 9 Ferry St., New York 7, N. Y. Model 102-

For TV and FM
R
H
Standardize on One!
Now, ONE crystal holder will cover your requirements for television and frequency modulation transmission. RH-7 hermetically sealed crystal units offer a frequency range from 1 to 75mc, to tolerances as close as .0002%. Space-saving, easily installed and replaced, RH-7 crystals will fit all circuits. Two pin sizes or wire leads are available.
Why not standardize now, on just ONE!
REEVES HOFFMAN
CORPORATION
CHERRY AND NORTH STREETS • CARLISLE, PA.

It's here!

The NEW General Electric
Variable Reluctance Cartridge
for Long Playing Records



- Specifically designed for the new long playing records . . . high compliance : . . low mass stylus assembly
- Equipped with 1 mil tip radius sapphire stylus
- Can be used with standard G-E preamplifiers

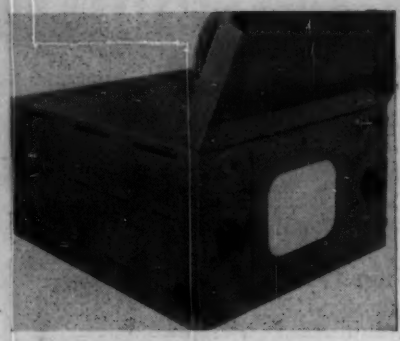
Place your order today!

General Electric Company, Electronics Park, Syracuse, New York

168-G10A

You can put your confidence in—

GENERAL ELECTRIC



MPS portable television picture monitor has a maximum resolution in excess of 500 lines and employs a 7-inch electromagnetic deflection picture tube. The equipment operates with a minimum video input signal 1 volt peak-to-peak.

Line Match Indicator

AERONAUTICAL COMMUNICATIONS EQUIPMENT, INC., 3090 Douglas Road, Miami, Florida. Model LMI-

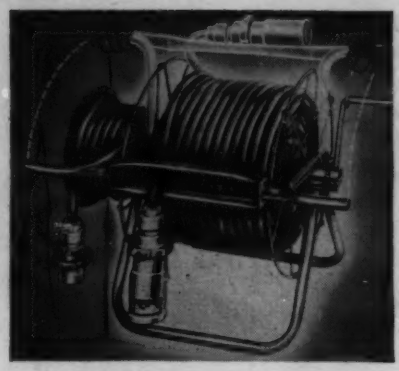
500 illustrated is a device for aiding adjustment of load for optimum line match at frequencies from 0.2 to 2 mc, or 2 to 20 mc. Model LMI-72 is used for coaxial lines at frequencies between 0.2 and 10 mc.

Rotary Beam Calculator

GORDON SPECIALTIES CO., 542 S. Dearborn St., Chicago 5, Ill. Dimensions for various types of beam antennas to operate in the region between 10 and 30 megacycles can be found quickly with a new calculator. Values for capacitance and inductance required for resonance between 5 and 60 mc are given, along with other information such as length of supporting boom required for various arrays. Price direct is $1.60 which includes postage.

Cable Reel

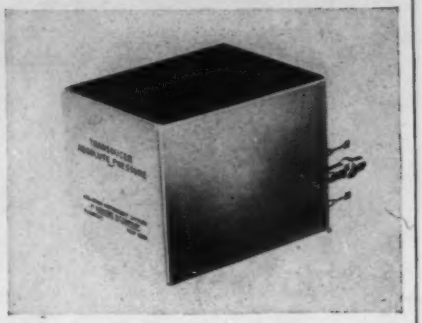
INDUSTRIAL ELECTRICAL WORKS, 1509 Chicago St., Omaha 2, Ne-



braska. With a capacity of 300 feet of ¾-inch four-conductor cable, or equivalent, the Powereel illustrated can be used for all types of cables. Each reel has either three or four collector rings of beryllium copper with double contact copper brushes.

Transducers

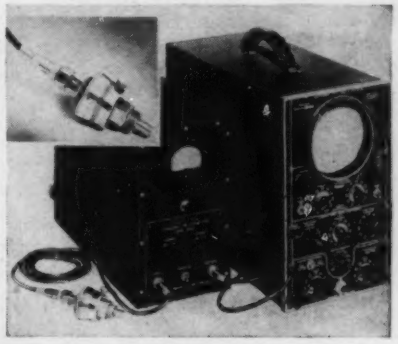
KOLLSMAN INSTRUMENT DIVISION, 80-08 45th Ave., Elmhurst, N. Y. Important in flight testing and con-



trol applications for pilotless aircraft the new, small transducers, one of which is illustrated, provide means of obtaining electrical signals that are functions of air speed, altitude, differential pressure, and gage pressure.

Dynamic Micrometer

ELECTRO PRODUCTS LABORATORIES, INC., 549 W. Randolph St., Chicago 6, Ill., has developed a dynamic mi-



a leash for atomic energy

. . . the end result of C-T metallurgy teamed with the engineering ingenuity of Radiation Counter Laboratories, Inc.

The Geiger Muller counter* is no stranger to the electronics engineer. Its sensitivity is beyond the realm of mathematical definition. But not so well-known are the difficulties encountered in producing a tube that is as sturdy as it is sensitive. And that is where we, as metallurgical specialists, have been of more than usual assistance to design engineers.

If you use components of tungsten, molybdenum, silver, platinum, palladium or alloys of these metals consult with our engineers. Conceivably, from the wealth of our experience we may be able to help you produce your product more economically. *Catalog No. 156 on request.*

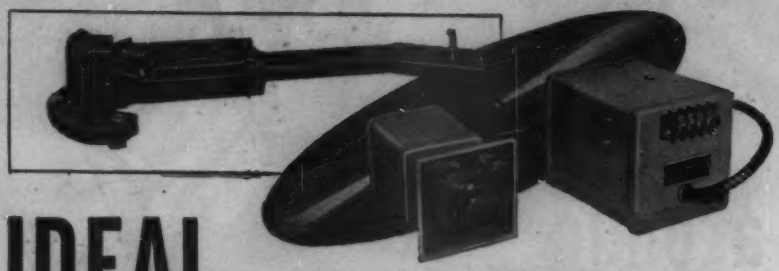
Callite Tube Components

Callite Tungsten Corporation
544 Thirty-ninth St., Union City, N. J.

**Manufactured by the well-known Radiation Counter Laboratories, Inc. of Chicago.*

Hard glass leads, welds, tungsten and molybdenum, wire, rod, sheet, formed parts, and other materials for incandescent lamps and electronic tubes.

GRAY TRANSCRIPTION ARMS and EQUALIZERS



IDEAL *for the* ***New LP Records***

The GRAY TRANSCRIPTION ARM 103-LP, with Selected GE Variable Reductance Cartridge with 1 mil Diamond Stylus, has been especially designed for use with the new LP Micro-Groove Records. Due to such features as **adjustable stylus pressure, frictionless motion, self-leveling base** and **the accommodation of any standard cartridge,** arm obsolescence is precluded. Arm, with 1 mil Diamond Stylus Cartridge, $77.95.

The GRAY #601 4-position EQUALIZER for GE Cartridge, finest performance and workmanship, ideal response curves. Adopted by radio networks. Matches pickup to microphone channel. Complete, $49.50.

Inquiries invited for development and manufacturing.

GRAY RESEARCH & DEVELOPMENT COMPANY, Inc.

16 ARBOR STREET HARTFORD 1, CONN.

—more compact, higher accuracy!

TYPES WL ⅝ and WLA ⅝ — ½ WATT INDUCTIVE

MAX. RES: .01 to 7,500 ohm (331 Alloy)
.01 to 4,000 ohm (Nichrome)
.01 to 1,250 ohm (Manganin)

BODY SIZE: ⅝" lg. by 3/16" diam.
TOLERANCE: STANDARD 1%

TYPES WL and WLA — 1 WATT INDUCTIVE

MAX. RES: .01 to 15,000 ohm (331 Alloy)
.01 to 8,000 ohm (Nichrome)
.01 to 2,500 ohm (Manganin)

BODY SIZE: 1" lg. by 3/16" diam.
TOLERANCE: STANDARD 1%

Can be supplied non-inductive with one-half indicated maximum resistance.

IN-RES-CO APPLICATION-DESIGNED RESISTORS

Economical in Cost

IN-RES-CO WL series resistors were designed to meet increasing demands for a compact resistor of high accuracy priced for general use. They meet the most critical requirements—close tolerance, ability to withstand overload, long life. Write today for catalog describing the full line of quality IN-RES-CO resistors.

IN-RES-CO

INSTRUMENT RESISTORS CO., 1056 COMMERCE AVE., UNION, N. J.

3½ KW VACUUM TUBE BOMBARDER or INDUCTION HEATING UNIT

Only $975

Never before a value like this 3½ KW bombarder or high frequency induction heater . . . for saving time and money in surface hardening, brazing, soldering, annealing and many other heat treating operations. Is

Portable . . . mounted on four rubber coasters. Width 14½"; depth 27"; height 42½"; weight 300#.

Operates from 220 volt line. Complete with foot switch and one heating coil made to customer's requirements. Send samples of work wanted. We will advise time cycle required for your particular job. Cost, complete, only $975. Immediate delivery.

Scientific Electric Electronic Heaters are made in the following ranges of power: 1-2-3-5-7½-10-12½-15-18-25-40-60-80-100-250. KW.

Scientific Electric

Division of

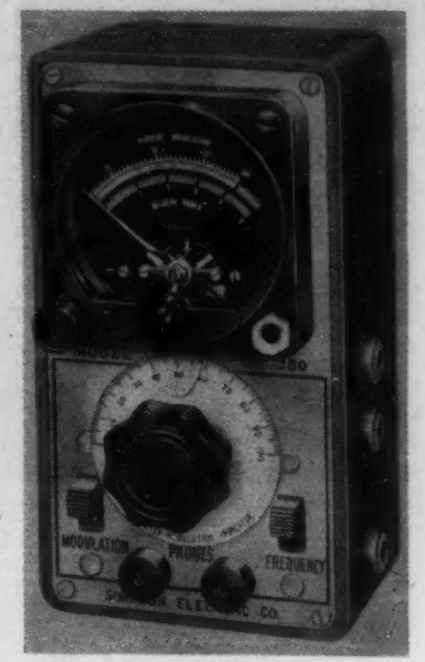
"S" CORRUGATED QUENCHED GAP CO.

105 - 119 Monroe St., Garfield, N. J.

crometer for measuring movement, radial displacement, or vibration of any part made of ferrous material. Displacement is read in tenths of a thousandth of an inch and accuracy is the same for a static condition as for a dynamic condition corresponding to speeds up to 200,000 rpm. Total weight is 27 pounds.

Wavemeter

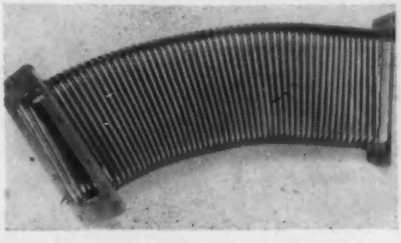
SIMPSON ELECTRIC Co., 5218 West Kinzie St., Chicago 44, Ill. Model



380 wavemeter is a pocket-size instrument for use by amateurs, ships, police radio, and similar services. Provision is also made for checking percentage of modulation. Separate coils are provided for the 10 to 80-meter amateur bands. A 2-foot antenna is furnished to be plugged into a jack on the instrument. Frequencies as high as 420 megacycles can be checked.

Flexible Waveguide

AIRTRON, INC., 650 Bloomingdale Road, Staten Island, N. Y. A new type of convoluted bellows electro-



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MODEL S20X
Equipped with convenient slide-lock switch for on-off operation.

MODEL SR20X
Equipped with built-in push-to-talk relay switch and cable.

High performance at low cost

On every count the new Turner Model 20X has won the vote of users. Response to voice and music pickups is smooth and even over a desired range of frequencies. Output level is remarkably high. Engineered for dependable service indoors or out with high quality moisture sealed crystal circuit. Light in weight, natural to hold, and most convenient to use. It is equipped with hook ring for hanging. Attractive case is finished in rich baked brown enamel. And the price, complete with 7 ft. cable is exceptionally low.

Write for Complete Microphone Literature

THE TURNER COMPANY
905 17th Street N. E. Cedar Rapids, Iowa

Crystals licensed under patents of the Brush Development Co.

TURNER

Microphones BY TURNER

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The G.M. counter tube reaches maturity in the new all metal *THYRODE 1B85

The new THYRODE is a precision counter tube, designed to utilize quantity production methods. The .005 inch aluminum wall, rib re-enforced, adds strength to its inherent stability and accuracy.

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CHARACTERISTICS

Overall length	4-1/8 inches
Active length	2-3/4 inches
Shell diameter	3/4 inches
Absorption	30 mgm/cm²
Operating voltage (center of plateau)	900 volts
Plateau length	200 volts
Plateau slope	3% / 100 volts
Temperature range	5° C. to 70° C.
Life	10^8 counts

*THYRODE
A Victoreen trademark for radiation counter tubes

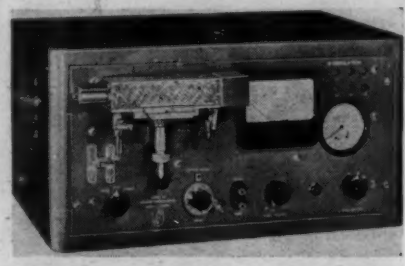
Victoreen radiation measuring instruments for laboratory and field determinations together with such components as the VX series subminiature electrometer tubes, vacuum sealed hi-meg resistors and G-M counter tubes have made notable contributions to the present refinement of radiation instrumentation.

Victoreen 5806 Hough Avenue Cleveland 3, Ohio

plated flexible waveguide is now available having an electrical impedance matching that of rigid waveguide. Sizes down to that required for 1 cm can be supplied.

Alpha Counter

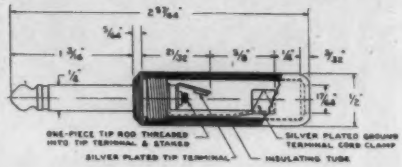
INSTRUMENT DEVELOPMENT LABORATORIES, INC., 223 West Erie St., Chicago 10, Ill. Model 117 alpha



counter will count alpha particles in the presence of a strong beta background. Unit consists of a methane flow proportional counter, high-gain amplifier, scaler (256 to 1), impulse recorder, and variable high-voltage supply.

Phone Plug

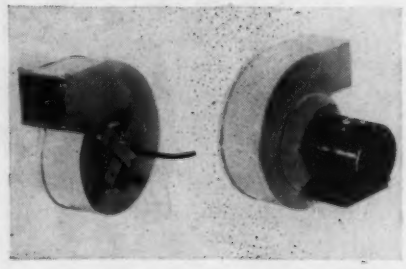
SWITCHCRAFT, INC., 1328 N. Halsted St., Chicago 22, Ill. The Little-


ONE-PIECE TIP ROD THREADED INTO TIP TERMINAL & STAKED
SILVER PLATED TIP TERMINAL
INSULATING TUBE
SILVER PLATED GROUND TERMINAL CORD CLAMP

Plug illustrated features a sleeve terminal that can be clamped over the metal braid of shielded wire cables to form both mechanical anchor and electrical connection. If the terminal is used only for mechanical anchorage an extra lug can be used for connection to the sleeve of the plug.

Blowers

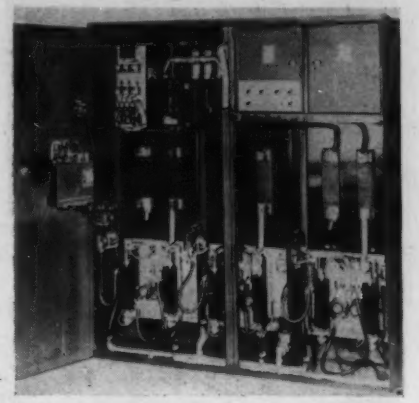
JOHNSON FAN & BLOWER CORP., 1319 W. Lake St., Chicago 7, Ill. Type 5CB centrifugal fans have a



wheel diameter of 5 inches. Various sizes of motors and different fan combinations can be furnished for many applications in cooling electrical and electronic equipment.

Multiple Control Unit

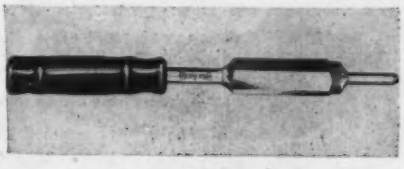
WELTRONIC CO., 19446 W. Eight Mile Road, Detroit 19, Mich. Model 312KS2, a 3-phase multiple control combination, has a remote control



relay timer which provides a variety of multiple welding sequences with independent dial adjustment of weld time on each phase. Automatic control circuit protection is incorporated. Write for detailed information on standard and supplementary equipment.

Plug-Tip Soldering Iron

HEXACON ELECTRIC CO., 130 W. Clay Ave., Roselle Park, N. J.



Model P212 electric soldering iron is rated at 200 watts with a half-inch diameter tip.

Literature

C-R Tube Primer. Allen B. DuMont Labs., Inc., 1000 Main Ave., Clifton, N. J. A 63-page manual presents an excellent nontechnical discussion of the cathode-ray tube and its functions. The book is available without cost to anyone professionally engaged in electronics or teaching the sub-

that keeps in step with Progress

THE problem of meeting new power and frequency requirements in communications systems, with minimum obsolescence, is solved by the Telepak line of transmitting equipment, the latest achievement in this field by Radio Receptor.

Telepak consists of a basic frame supporting a series of separately and easily removable units or cells of standard construction, varying in height according to power requirements. These unit assemblies are housed in standard cabinets, as illustrated.

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ject, and others may obtain it at 50 cents per copy, or at $2.50 in lots of a dozen.

Data Handling Systems. Teleregister Laboratories, 157 Chambers St., New York 7, N. Y. The engineering services available for teleregister systems covering everything from parimutual totalizers to inventory and production control are described and representative equipment is illustrated in a 24-page booklet.

Motor Speed Control. Servomechanisms Inc., Mineola, N. Y. The new motor speed control SC104 provides a speed range of 40 to 1 for armature output of 5,000 rpm maximum. Torque-versus-speed curves are given in a page descriptive sheet.

Connector Catalog. American Phenolic Corp., Chicago 50, Ill. Catalog A-1 on AN connectors and fittings for power, signal, and control circuits, lists thousands of sizes and graphically illustrates the different types of shells and insert arrangements available for each. Dimensions and electrical data are shown in detail.

Magnetic Tape Recorders. Ampex Electric Corp., 681 Fifth Ave., New York 22, N. Y. An 8-page booklet describes and illustrates chief features of the model 200-A magnetic tape recorder. The unit has already been tested on continuous commercial network operation.

Tube Information. Radio Corp. of America, Harrison, N. J. Technical data on types 6BA7 and 12BA7 pentagrid converters has been published, as well as application notes on receiver sensitivity measurements at high frequencies, and a brochure on improved arrangement of base pin connections in new miniatures.

Attenuator Pad. Weinschel Engineering Co., 123 William St., New York 7, N. Y., has issued a folder describing the model 50-L/p-x coaxial attenuator pad with atten-

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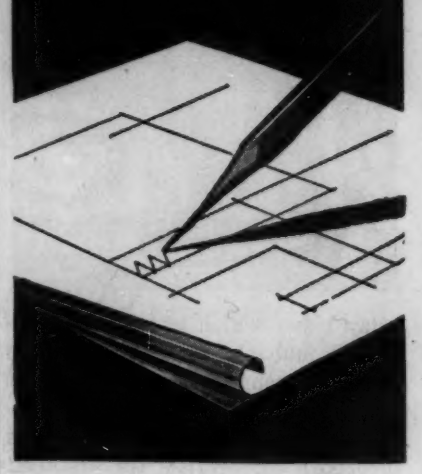

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Tube Data. General Electronics, Inc., 101 Hazel St., Paterson, N. J. A recently issued folder gives technical data for a large line of transmitting tubes, rectifiers and vacuum capacitors. Prices are also listed.

Recording Wire. Fidelitone Inc., 1616 Devon Ave., Chicago 26, Ill. Bulletin No. 9 gives informative and semitechnical data comparing the 0.004 and 0.0036-inch diameter wire for magnetic wire recording.

Electrical Insulation. Insulation Manufacturers Corp., 565 West Washington Blvd., Chicago 6, Ill. Outstanding features of the Dieflex varnished tubings or sleevings are set forth on two sides of a sheet. A variety of grades and sizes of the products may be obtained.

Radio Link Equipment. Federal Telecommunication Laboratories, Inc., 67 Broad St., New York 4, N. Y. Special features, illustration and general description, and technical characteristics of a variety of radio link equipment, a monitor, and dummy load are treated in five loose-leaf folders now available.

Quartz Crystals. Reeves-Hoffman Corp., Carlisle, Pa. Bulletin RHC-X covers an assortment of crystal units ranging from 50 kc to 100 mc. Ordering instructions are included.

Automatic Controls. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa., has issued a newly-revised, 40-page catalog on position-adjusting and electrically-actuated control equipment. Both Micromax and Speedomax instruments are listed. Ask for catalog ND4A(1).

Tube Catalog. Amperex Electronic Corp., 25 Washington St., Brooklyn 1, N. Y. The new 296-page

Investigate

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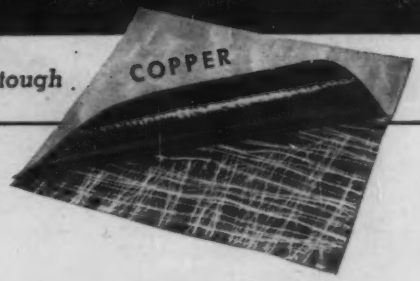
Reinforced with tough  *Sisal Fibres*

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catalog covers a line of electronic tubes for communications, industrial, amateur, and electromedical uses. Contents are grouped under four headings: air-cooled power tubes, water and forced-air cooled power tubes, rectifier tubes, and vacuum capacitors. Full data are given on each tube. A formal request to Amperex will bring your copy to you.

Magnetic Sub-Assemblies. General Electric Co., Chemical Dept., Pittsfield, Mass. Booklet CDM-16 describes and illustrates a line of permanent magnet sub-assemblies for engineering and production economy. Ordering instructions are included.

Sound Products Catalog. Radio Corp. of America, Engineering Products Department, Camden, N. J. Catalog 218P lists in 84 pages a complete line of sound equipment. Concise descriptions of each model include such information as special features, uses, specifications, photographs and diagrams.

Electrical Tapes. Minnesota Mining & Mfg. Co., 900 Fauquier Ave., St. Paul 6, Minn., announces a new 24-page two-color catalog describing 39 Scotch brand electrical tapes. Tape properties are listed and eighty-six applications illustrated.

Radioteletype Converter. George J. Maki, Radiotelegraph Engineering, Moraga, Calif. Description, block and circuit diagrams, and specifications of the model RC-55 frequency-shift radioteletype converter may be found in a new booklet.

Vacuum Measurement. George E. Fredericks Co., Bethayres, Pa., has available a new 28-page booklet on vacuum measurement. Written in nontechnical language, it is intended for the layman interested in the proper selection and use of vacuum gages for industrial processes.

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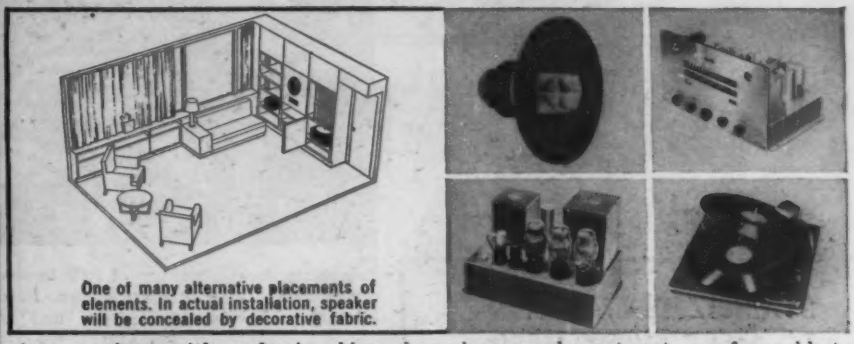

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As an engineer with professional knowledge of the science of audio reproduction, you can appreciate more thoroughly than any layman the incredible life-like reproduction of voice and music of which this magnificent Altec Lansing Home Music System is capable. Added to the lifetime enjoyment which this system will provide is the pleasure of installing it yourself. Full instructions are included. This system transcends the inherent limitations of commercial radio-phonographs, yet costs are favorable to this system. The system includes the famous Altec Lansing Duplex speaker, a special Altec Lansing amplifier, a newly designed TRF Altec Lansing tuner, and the Webster 70 changer. Built-in Altec Lansing Daylight Television can also be included.

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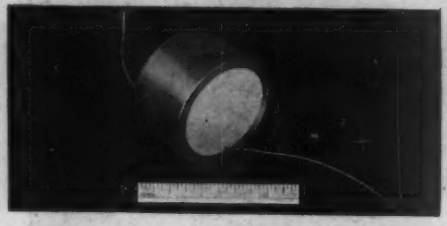

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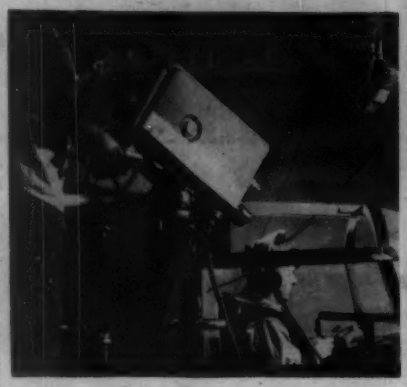

Televising cockpit mockup of P2V Neptune during Navy flight training lecture. Studio has two GE cameras like this and two DuMont cameras

vision receivers of various types will be used under a variety of conditions and with screen sizes ranging from that of a 10-inch tube on up to that projected onto a 9 by 12-foot screen. Also under investigation will be methods of instruction best adapted to the television medium and the design of the ideal television classroom. Tryouts of talk-back circuits are contemplated, so that students anywhere in widely scattered classrooms can ask questions of the instructor during or after a lecture.

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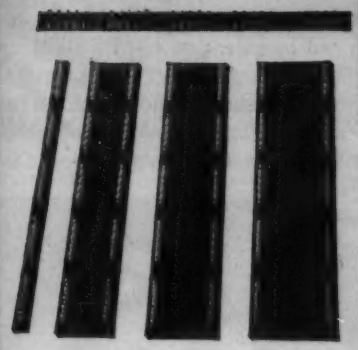

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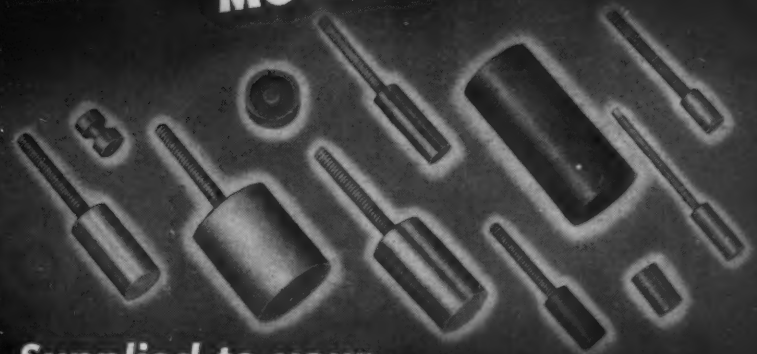

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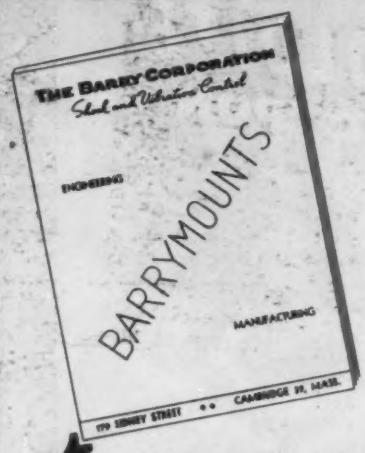

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Many Designers and Engineers will use this Barry Catalog as a reference book. It contains Fundamental Vibration Charts, describes basic problems in shock and vibration control.

The new catalog illustrates and describes Barrymounts and their applications.

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We offer a complete line of highly engineered Vibration and Impact isolators for commercial, industrial, and military applications . . . also an engineering consulting service on special problems.

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structor clearly. The television camera scales demonstration models up or down to proper size for most effective training.

With television, usable portions of obsolete motion picture training film can be salvaged and brought up to date by combining with personal demonstrations. Students lose interest in films showing obsolete planes, for instance, yet basic principles involved remain the same. Unparallelled flexibility in choice of instruction material is another advantage. The lecturer can change at will from models to artwork, maps, diagrams, motion pictures, film strips, slides, demonstration devices, training devices and actual service gear.

Two 35-mm slide-strip film projectors and a 16-mm sound film projector here feed into a GE film camera located under the control room of the Navy's television studio at Sands Point, Long Island. Two full-silvered front-surface mirrors make possible permanent mounting of all three sources, any of which can be cut into a studio program at will

Though television offers promise of better instruction, it does not eliminate all instructors. Rather, it permits use of local laboratory instructors and assists them with the best of lecture help. It is not intended for teaching all subjects; introduction sessions to courses and the more difficult sessions offer greatest promise. Whether television will actually reduce learning time through use of new and more effective techniques is not yet known.

Radio Parts Show and RMA Silver Anniversary

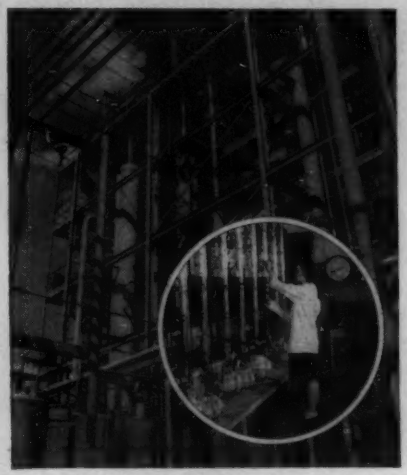
PLANS HAVE BEEN made for a gala radio industry celebration in Chicago during the week of May 15, 1949, combining the RMA Silver

Silicone News

DC SILICONES

HUNDREDS OF AUTHORS

Thanks to the cooperative efforts of hundreds of scientists and engineers in almost every field of industry, we have been able to compile a comprehensive new booklet about DC 200 Fluids.



In early 1943 glass distillation columns supplied the demand for silicone products. By 1944, we had completed a multi-million dollar plant to supply war time requirements. During the past four years plant capacity has been tripled to supply the domestic and foreign markets.

We had been producing DC 200 Fluids for less than a year when we published a 4-page leaflet describing these remarkably stable silicone fluids. Our newest publication is a 32-page booklet describing some of the more typical applications and giving data on the more significant properties of the DC 200 Fluids.

This volume of information is evidence of a unique and useful combination of properties in the fluids themselves. It is proof of the ready acceptance given to these basically new materials by scientists, engineers and technicians in almost every industry. They have improved the performance of all sorts of devices by capitalizing on the properties of DC 200 Fluids. We, in turn, have gained knowledge and experience by giving technical assistance.

The benefits of our years of research and experience in producing DC 200 Fluids and in adapting them to many different applications are made available in booklet No. N-C-13. We hope that you will call on the technical representatives assigned to each of our branch offices for any additional information or assistance.

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Essex *One-Source* service handles the intricate job of producing lighting, ignition and control harness assemblies *custom-built* to your exact specifications and *complete* with all manual and electrical control devices for quick, efficient installation.

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General Electric Model XFM-1

Post-war version of the old G.E. J.F.M-90 Translator which was used and enjoyed by tens of thousands of discriminating radio listeners.

Covers 88-108 mc range, dial 12 inches long, uses guillotine tuning for highest efficiency, high stability. Designed for export, has power inputs for 110 to 250 volts, 50/60 cy. Used in conjunction with good audio section or separate amplifier will provide best FM listening you ever heard. In attractive natural walnut cabinet — 10¾" high x 15¾" wide x 11⅜" deep, complete with 8 tubes. Tropic-proof construction. Quantity limited.

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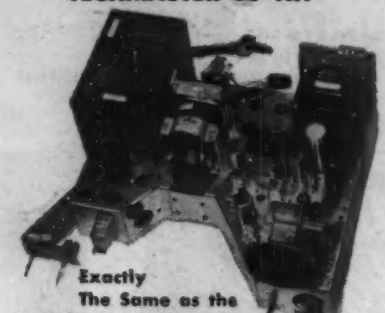

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Anniversary convention and the annual Radio Parts Industry Trade Show. Events will be climaxed by a banquet on Thursday, May 19, at the Stevens Hotel.

The Parts Show management also decided to broaden the eligibility rule for exhibits by parts and components manufacturers to give limited exhibition privileges in the 1949 show to parts manufacturers selling to set manufacturers or other industrial outlets, in addition to manufacturers selling to jobbers, heretofore admitted.

IRE Fellowships

AT THE SEPTEMBER meeting of the IRE board of directors, the following members of the Institute were elected to the grade of Fellow:

H. A. Affel of Bell Telephone Laboratories, New York, N. Y., K. C. Black of Aircraft Radio Corp., Boonton, N. J.; J. E. Brown of Zenith Radio Corp., Chicago, Ill.; Cledo Brunetti of National Bureau of Standards, Washington, D. C.; W. L. Carlson of RCA Laboratories, Princeton, N. J.; P. S. Carter of RCA Labs, Rocky Point, N. Y.; F. E. d'Humy of Western Union Telegraph Co., New York, N. Y.; John N. Dyer of Airborne Instruments Laboratory, Mineola, N. Y.; L. A. Gebhard of Naval Research Laboratory, Washington, D. C.; T. T. Goldsmith, Jr. of Allen B. DuMont Laboratories, Passaic, N. J.; F. W. Grover of Union College, Schenectady, N. Y.; E. A. Guillemin of MIT, Cambridge, Mass.; Ross Gunn of U. S. Weather Bureau, Washington, D. C.; A. V. Haeff of Naval Research Laboratory, Washington, D. C.; L. C. Holmes of Stromberg-Carlson Co., Rochester, N. Y.; J. Kelly Johnson, consulting engineer, New York, N. Y.; S. R. Kantebet of the Government of India Overseas Communication Service, Bombay, India; W. B. Lodge of Columbia Broadcasting System, New York, N. Y.; K. A. MacKinnon, consulting engineer, Ottawa, Ontario, Canada; H. F. Olson of RCA Laboratories, Princeton, N. J.; G. D. O'Neill of Sylvania Electric Products, Inc., Flushing N. Y.; L. S. Payne of Canadian Marconi Co., Ltd., Montreal, Canada; L. M. Price of Radio Valve Co. of Canada, Toronto, Canada; H. J. Reich of Yale University, New Haven, Conn.; J. D. Reid of Crosley Division of Avco Mfg. Corp., Cincinnati, Ohio; Karl Spangenberg of Stanford University, Calif.; George Sterling of the FCC, Washington, D. C.; C. E. Strong of Standard Telephones and Cables, Ltd., New Southgate, London, England; Franz Tank, Institut fur Hochfrequenz Technik, Zurich F, Switzerland; W. N. Tuttle of General Radio Co., Cambridge, Mass.; I. R. Weir of General Electric Co., Syracuse, N. Y.

It was also announced by the board that the Institute's Medal of Honor would be awarded to Ralph Bown, director of research at Bell Telephone Laboratories and member of the Joint Technical Advisory Committee of the RMA and IRE.

Midwest Television Networks

FIVE TELEVISION affiliates of NBC are now linked in a new midwestern coaxial cable network. Participating stations are WBEN-TV, Buffalo, N. Y., WSPD-TV, Toledo, O.;

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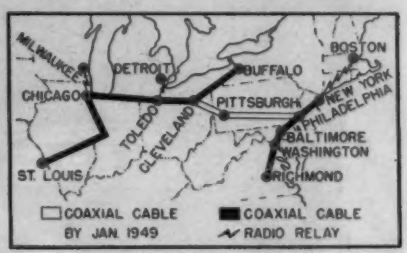
WWJ-TV, Detroit, Mich.; WTMJ-TV, Milwaukee, Wis.; and KSD-TV, St. Louis, Mo.

The pioneer NBC group listed above will soon be expanded to other cities in the area, including WNBQ, Chicago and WNBK, Cleveland. It is expected that by January 1 the midwestern net will be linked with the NBC television network now spanning the eastern seaboard.

Also in operation for telecasting of presidential election returns was ABC's six-station midwestern television network, comprising KSO-



TV in St. Louis, WTMJ-TV in Milwaukee, WSPD-TV in Toledo, WXYZ-TV in Detroit, WEWS in Cleveland and WBEN-TV in Buffalo. As this lineup indicates, midwestern television stations are in some instances joining two networks.

National Electronics Conference Program

Two outstanding features of the 1948 National Electronics Conference at the Edgewater Beach Hotel, Chicago, November 4, 5, and 6, will be the banquet in the Marine Dining Room on Thursday evening, November 4, and a large-screen television demonstration by RCA in the Crystal Ballroom on Friday at 8:00 p.m.

The technical program is as follows:

Thursday, November 4

9:00 a.m.—Registration, Edgewater Beach Hotel, Chicago

10:00 a.m.—Session 1: NEW MATERIALS

Properties of CbN at Radio Frequencies, by J. V. Lebacqz and Donald H. Andrews of Johns Hopkins University.

Development and Properties of Some Ceramic Dielectrics, by G. R. Shelton, E. N. Bunting and A. S. Creamer of National Bureau of Standards.

The Transistor—Its Properties and Characteristics, by Walter H. Brattain of Bell Labs.

10:00 a.m.—Session 2: SOUND MEASUREMENT—RECORDING

Application of Miniature-Circuit Techniques to the Sound Level Meter, by H. H. Scott of Hermon Hosmer Scott, Inc.

An Evaluation of the Application of New and Old Techniques to the Improvement of Magnetic Recording Systems, by

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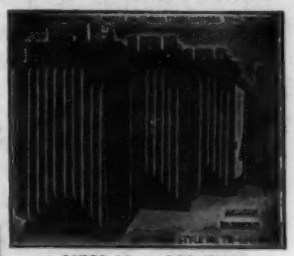

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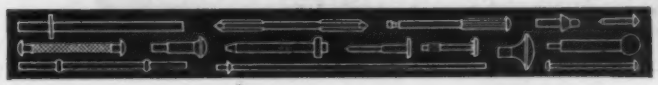

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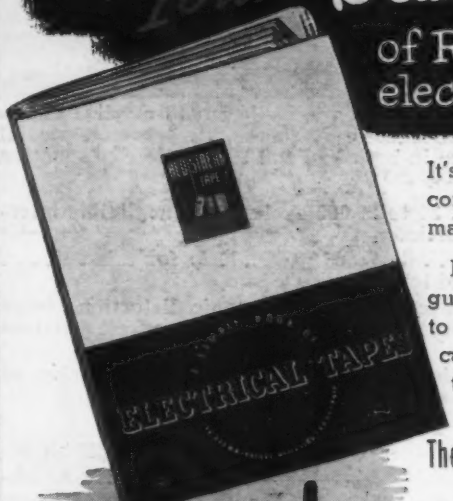

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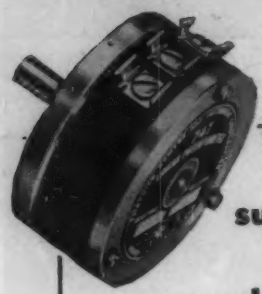

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Extended listening range . . . 30 to 20,000 cycles, with negligible intermodulation or transient distortion,

**Dynamic noise suppressor* . . . designed particularly for this unit . . . allows widest use of high- and low-frequency gain,

Twenty-watt output . . . with less than 2% harmonic distortion; range and power-handling capability exceed RMA broadcast station requirements,

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tablished fellowships at Stanford University and MIT to help young men obtain advanced degrees in the field of communications and electronics.

RADIO CORP. OF AMERICA, Camden, N. J., recently held a four-day television seminar for 40 consulting engineers.

FEDERAL TELEPHONE AND RADIO CORP., Clifton, N. J., has installed a modernized f-m two-way radio system in place of the former a-m equipment in 215 mobile units on

One of five fireboats operated by the Baltimore Fire Department. It is equipped with Federal's 2-way f-m mobile radiotelephone

land and water, for police and fire department operations in Baltimore, Md. The units will operate in the 152 to 162-mc band. Changeover took place without interrupting the city's 24-hour service.

PERSONNEL

GEORGE C. KUCZYNSKI, attached to the staff of Sylvania Electric Metallurgical Laboratory, Bayside, N. Y., for basic research on the electron theory of metals, delivered a series of lectures on the physics of metals at the National University, Bogota, Columbia.

H. MYRL STEARNS, formerly in charge of the Tube Research and Development Laboratory and of tube production at Sperry Gyroscope Co., has been appointed vice-president and general manager of

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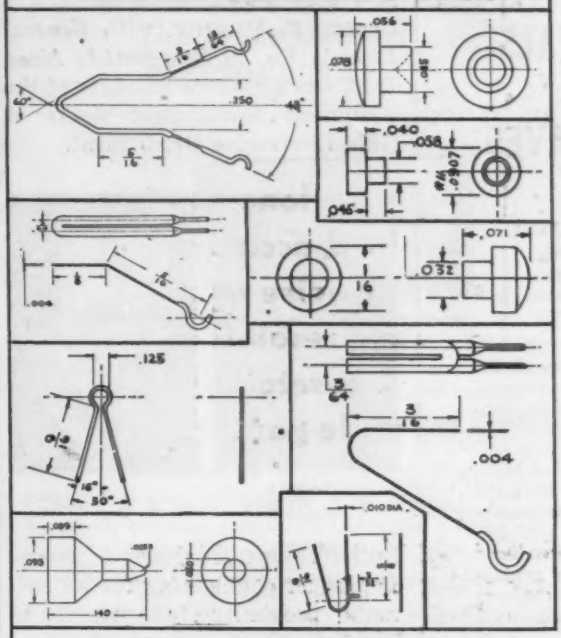

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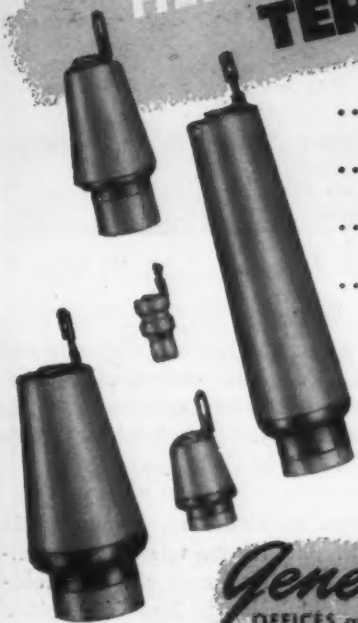

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E-11-48

Varian Associates, new microwave and electronic research and development laboratory at San Carlos, Calif.

GEORGE F. MURPHY, with General Electric Co. in Schenectady since 1913, was appointed manager of the equipment development works of GE's Electronics Department.

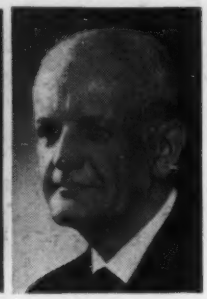
G. F. Murphy

J. T. Lucas

JOHN T. LUCAS, formerly in charge of product engineering for all Sylvania proximity fuze plants in Pennsylvania, has been appointed supervisor of quality control and customer service for the Huntington Radio Tube Plant of Sylvania Electric Products Inc.

A. C. GABLE, formerly assistant engineer, was recently appointed division engineer of GE's Tube Divisions, Schenectady, N. Y.

A. C. Gable



E. W. Stone

ELLERY W. STONE, executive vice-president of Federal Telephone and Radio Corp., has been elected president of that organization and its subsidiary, the International Standard Electric Corp.

EDWIN H. COLPITTS, holder of 24 U. S. patents on telephone inventions and director of the Engineering Foundation in New York since 1941, was presented with the 1948 Cresson Medal by the Franklin In-

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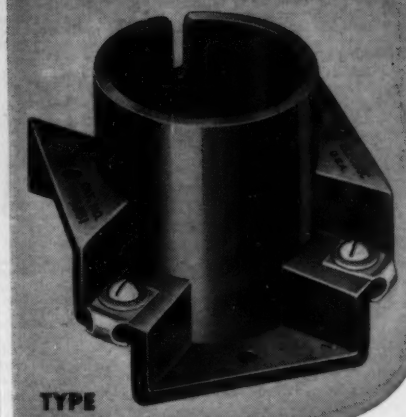

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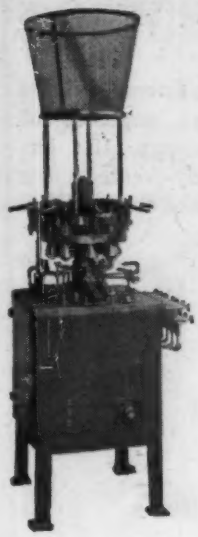

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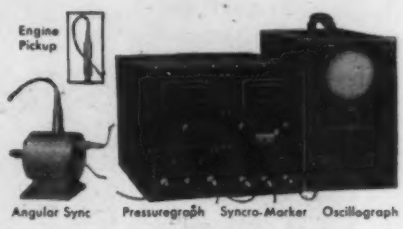

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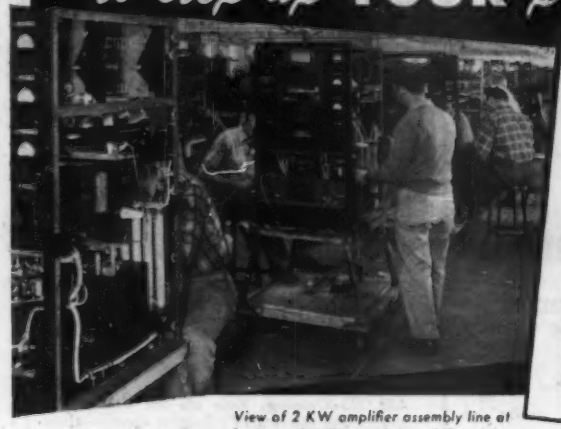

View of 2 KW amplifier assembly line at Barker and Williamson's Bristol, Pa. plant.

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C. RUSSELL COX, formerly sales manager and chief engineer of Andrew Corp., Chicago, Ill., has taken over the newly-created office of director of sales and engineering.

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JOHN S. BROWN, associated with Andrew Corp. since 1943, has been promoted from assistant chief engineer to chief engineer.

WALTER F. KEAN, in charge of the company's broadcast consulting division since 1944, is now sales manager at Andrew Corp., Chicago, Ill.

W. F. Kean

O. S. Duffendack

O. S. DUFFENDACK, until 1944 professor of physics at the University of Michigan where he directed research for 16 years, and now president, vice-chairman of the board and director of research for Philips Laboratories, Inc. at Irvington-on-Hudson, N. Y., was recently decorated with the ribbon of the King's Medal for Service in the Cause of Freedom, by the British Consul General, for services to the Allied war effort as division member and chief of a section of NDRC.

LEWIS W. CHUBB, director emeritus of the Westinghouse Research Laboratories and recipient of the 1947 John Fritz Medal, has retired after 43 years of scientific research.

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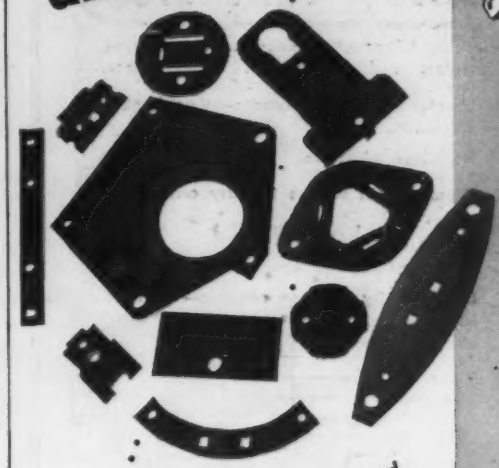

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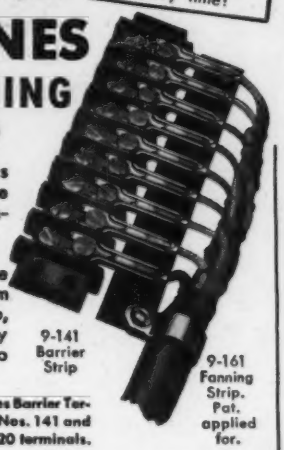

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NEW BOOKS

Vacuum Tube Circuits

BY LAWRENCE BAKER ARGUIMBAU, *Assistant Professor, Electrical Communication, Massachusetts Institute of Technology; John Wiley & Sons, Inc.* 1948, 668 *pages, price* $6.00.

IN A REALISTIC appraisal of the field, the author of a rather unusual book admits the temporary value of texts on electronics, so rapidly does the art change. His aim, therefore, is to equip students and engineers with the intellectual ability to solve problems rather than to describe equipment or circuits. He dissects circuits to their basic status, shows how to determine what these circuits do, and illustrates his methods with many useful examples. Problems are provided to test the reader's ability to learn from the text.

The book is unusual in that it does not follow the cut-and-dried pattern so customary in books on electronics. One is likely to find in an early portion of the book material usually discovered in the final chapter of the conventional book. The idea is not to present a slowly-developed and consistent treatment but to bring to the student the techniques of solving problems—in brief to aid the student to think.

In twelve chapters Professor Arguimbau treats many aspects of radio communication, diodes and rectifiers, triodes, pentodes and linear amplifiers, transient response in video amplifiers, amplitude modulation and tuned amplifiers, power amplifiers, oscillators, inverse feedback, amplitude and frequency modulation, pulses and television and microwaves.

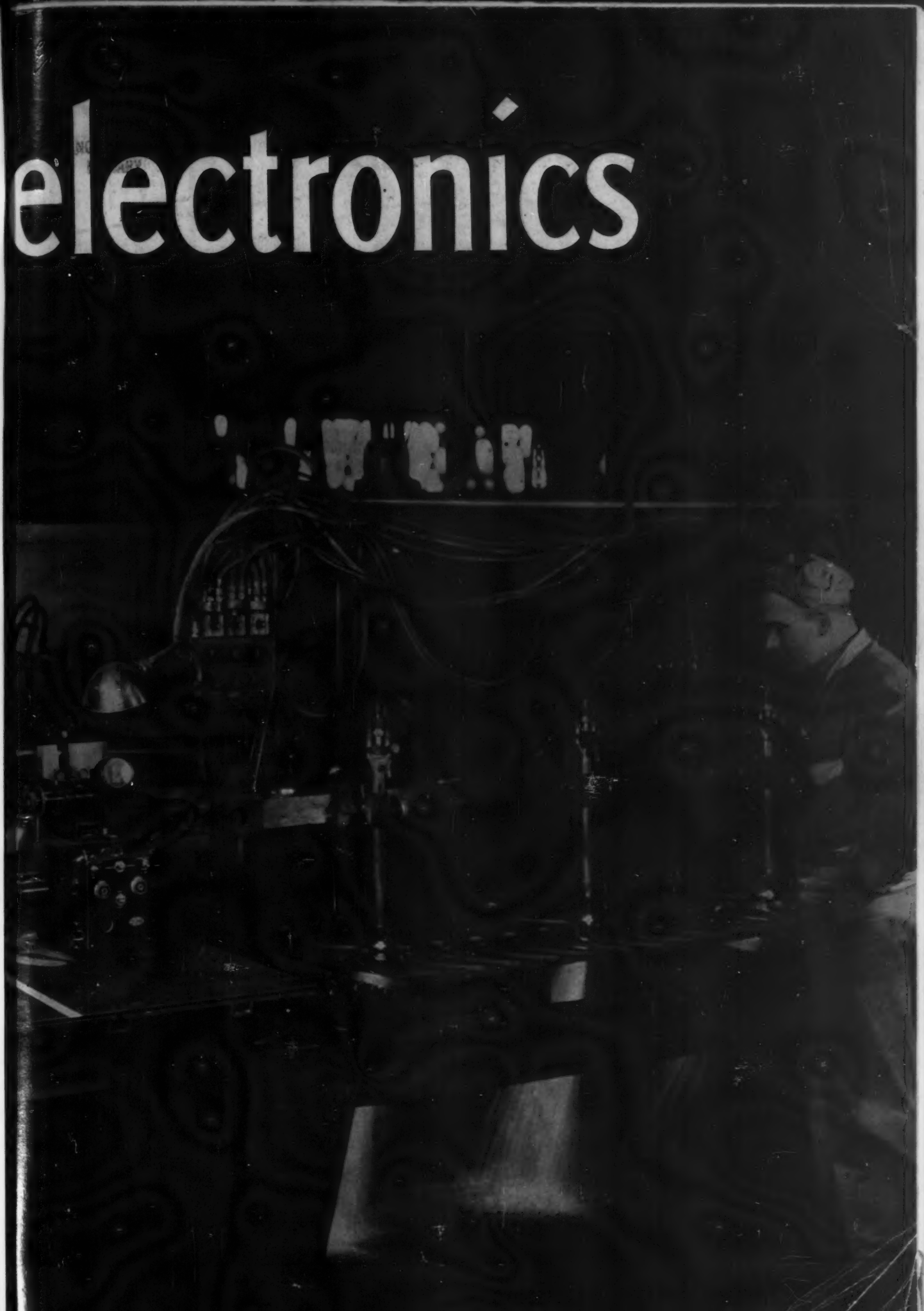
From unofficial reports, the author is a popular professor—and his book should be well received. —K. H.

Principles and Methods of Telemetering

BY PERRY A. BORDEN AND GUSTAVE M. THYNELL. *Reinhold Publishing Corporation, New York,* 1948, 230 *pages,* $4.50.

The material contained in this book fully justifies its title. Skillfully blending basic principles and current practice, the authors have produced a thoroughly practical text, of value to the potential user

electronics



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PHOTOELECTRIC CUTTING MACHINE ..... Cover
Motor-driven tracer of Air Reduction Sales Company unit follows intricate outline of paper template on table while oxyacetylene torches cut paper-mill pulp beaters in quadruplicate from three-quarter-inch low-carbon plate at Paper Calmenson Company plant in St. Paul. For technical details see p 122

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Ideas born of research must be promoted and pushed to overcome man's inherent opposition to change

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